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Engineering Estimates.

Estimates of the probable construction and operating costs of any proposed technical undertaking are perhaps the most important matters with which engineering experts in executive or advisory positions have to deal. There is room for a much wider appreciation of the value of the estimate, both from the standpoints of its preparation and its analysis by the client. No feature of a technical report upon the anticipated cost of a project betrays the experience of its author more clearly than the manner in which prices are collated, labor and material changes assumed, and approximations in totals allowed. From the point of view of the usual client, the final figures of an estimate and the recommendations based on them, if there be any in a report, contain the crux of the counsel purchased; but in not a few cases the failure to analyze the detailed reasoning upon which the totals are assumed opens the way toward serious consequences in the future. Reputation is of great importance in the preparation of engineering reports, but differences of opinion and judgment among even the most highly qualified professional men justify thorough examination of all the premises by the client. It is not a question of making lay decisions against trained recommendations; it is rather a matter of checking all vital conditions upon which assumptions are based.

Engineers of experience and broad judgment do not hesitate in modern estimate reports to present to the client their detailed assumptions and calculations. A narrow point of view would condemn this practice as likely to dissipate professional stock-in-trade, but in reality each project differs so much from all others in its conditions, that the need of technical judgment in all new work does not decrease an iota because of what may have been published or presented before. Under some conditions, of course, there appears to be little need of presenting detailed figures in estimates; the client requires an outside figure within a few hours and does not care to have the process by which the result was reached. That is the province of the engineer, but the failure to preserve such calculations and assumptions at some safe and accessible place has been the cause of endless trouble in the actual business world. The report is the natural repository of such figures, and there is no denying a definite tendency of practice to include them. Authority is much more convincing even to the layman, if there is no concealment of methods. In reporting recently upon the number of stations needed for the Cambridge, Mass., subway, Mr. Wm. Barclay Parsons did not hesitate to include several pages of detailed counts of passengers traveling on various cars at different hours as the principal basis of his final recommendations; and in submitting cost estimates of the proposed high-speed interurban electric line between Boston, Lynn and Salem to the Massachusetts Railroad Commission last week, Chief Engineer Bickford considered it worth while to present the detailed quantities and unit costs of materials, equipment and labor with multiplications and additions of items leading to the final total of over $8,000,000. These are but two cases out of hundreds which could be cited, but they illustrate the desire of the modern engineer as a professional man to be of the utmost possible use to his clients by withholding nothing which is the product of his experience.

The client no less than the engineer can do much more to help secure accurate estimates than is the case at present. Rapid work is demanded in the preparation of the majority of estimates connected with American industry, and the executive official often loses sight of the fact that a hasty estimate must be made much larger to cover contingencies than one prepared on carefully ascertained data. No engineer of reputation will report on the cost question at a few hours' notice without a liberal allowance for indeterminate or uncertain factors in the problem. Time must be allowed to secure provisional quotations from manufacturing companies and contractors, to calculate in round numbers the labor and material elements, and to compare data of various kinds, if anything like close figures are to be expected. In this connection there is not the least doubt that many delays could be reduced, if in asking for preliminary quotations, the manufacturers' representatives were notified that they are wanted for estimates rather than as competitive bids. The final quotation from the district office of a great manufacturing company in keen competition with its rivals represents the acute judgment of many minds. All this consumes time, while figures accurate enough for the great majority of estimates can be had at an hour's notice in some district agencies. Such quotations are often but single items in the whole scheme which the engineer must work up for his client, and their sifting and application, comparison and checking even approximately with previous work require time which the client is often unwilling to grant. The opportunity of the engineer to prepare and present the matter in detail enables the client to point out any general features of the case of possible oversight which changes or unlooked for conditions have brought about, and thus facilitates helpful co-operation.

Much may be learned by comparing estimates with actual costs when the work is under way or finished. This sort of analysis is not done with anything like the frequency which is desirable, and the failure to match up commercial results with predicted costs only opens the gate into the field of less accurate future work. It is often a painful task to sit down and go over estimates fairly and squarely with the unequivocating figures of construction and operation costs at hand; but it is about as wholesome a duty as can be mentioned. If discrepancies exist it is worth while to find out the reasons if possible, and to weigh the effect of hidden factors more carefully in future reports. Only a client of provincial instincts and nose-to-the-grindstone perspective will value the original careful estimate less because changed conditions have modified one way or the other the itemized or total costs anticipated originally.

The Bridging of Tunnels.

The primary idea of a tunnel is chiefly that of an opening through either sufficiently solid material to support itself safely and also the track and traffic, or through relatively soft material, firm enough to carry a fairly rigid structure and the traffic under any vibrations or other conditions of stress set up by the passage of trains. If the tunnel is through rock manifestly no questions of stability can arise except possibly those produced by the presence of water and other conditions causing slips; at most there can be no sagging or displacement of the bore of the tunnel. In comparatively soft material, however, which possesses some substantial degree of firmness but not enough to eliminate beyond all question the possibility of the movement of the tunnel tube under train vibrations, some question may arise in connection with the stability of the structure under the new conditions created by its building or under the subsequent passage of traffic. In gravel, stiff clay or other similar material there may be no more doubt regarding the fixedness of a tunnel tube during any supposable period of time than in rock, but there is a wide range of comparatively soft material in which the engineer does not now hesitate to build a tunnel, even though its firmness is so defective as to permit an empty tunnel tube to possess a marked tendency to rise or gradually to get out of line under the passage of the present heavy cars and locomotives unless well-considered precautions in design are taken. The modern train and the present electric street car have all gradually become far heavier than those used but a few years ago, and they are moved at much higher rates of speed than were considered either desirable or feasible at an equally short period in the past, and they introduce conditions of loading that must be considered in tunneling in soft materials.

When it is borne in mind that the depth required for the construction of a tunnel in a satisfactorily firm material is almost invariably much deeper than would be needed if the same tunnel could be held safely in the softer material lying above the former, it can easily be realized that any system of tunnel construction which may properly be employed in piercing the comparatively shallow and soft material and holding the tunnel firmly in it, cannot fail to be of value.

In the first place, the shallow subaqueous tunnel requires a correspondingly lower pressure of air in which the laborers must perform their work, and in the second place the softer material can generally be far more rapidly and cheaply removed. Both of these material factors lead to substantial economies in both time and cost, and they are of the highest importance not only to the engineer but to the owner of the tunnel.

On the other hand, when one reflects upon the conditions induced in a subaqueous tunnel tube carrying traffic it is not surprising that many engineers heretofore have hesitated to risk tunnel construction in too soft material, and without sufficient roof filling over the structure. A heavy train moving at even a moderate rate of speed tends to produce an advancing wave of vibrations throughout its length, creating a corresponding tendency toward a condition of looseness around the circumference of the tunnel structure and the accumulation of very thin material, if not water, in the same space. The pulsating continuance of these train vibrations might in many cases result in a material displacement of the tunnel structure. These results would be materially aggravated in case the empty tunnel were of less weight than the displaced water. Finally, if there should be any sensible settlement or displacement of the tunnel tube as ordinarily constructed, cracks might be formed leading to leakage.

In some of the latest tunnel work, such as the tunnels under the North River at New York, where the shield method was employed, the requisite excavation has been largely accomplished by forcing the shield forward through the relatively soft material, the latter not being excavated through the shield but forced aside by it. This leads to the most rapid tunnel tube completion yet reached, but it may possibly leave that tube in a condition of mud flotation unable in itself to take safely the tunnel traffic. It is well known that the tubes of the Pennsylvania railroad tunnel between Jersey City and Manhattan are to be supported at suitable intervals by large iron screw piles put down through openings in the bottom of the tube. In this manner the tunnel in soft material becomes practically a continuous bridge supported upon screw pile piers.

Again, portions of the Rapid Transit subway tunnel under the East River between South Ferry and Brooklyn were driven in sandy material of such character that it has been thought best to reinforce the support of the tubes afforded by the natural material by concrete piles sunk through the bottom of the tubes by the aid of a water jet in a manner fully set forth in The Engineering Record of June 8. In this case, as in that of the Pennsylvania R. R. tunnels, the supporting concrete piles make the piers of a continuous bridged tunnel. The same general end was attained in the McBean system of constructing the Rapid Transit subway tunnel under the Harlem River. In this latter place the entire tunnel structure is supported upon timber or other piles driven in the ordinary way at any desired distance apart and cut off at the proper elevation, no roof filling whatever being required over the finished tunnel. These cases of actual construction exhibit the latest as well as perhaps the most important development of modern tunneling operations.

Low-Priced Illuminating Gas in Hamilton, O.

Hamilton is a city of about 30,000 inhabitants, situated in the southwestern portion of Ohio, some twenty-five miles from Cincinnati. It has two railroads, water-works, trolley lines, electric lights, gas supply, various manufacturing establishments, and altogether is a typical Middle Western city among those of its size. It is of interest at present because of the conditions surrounding its gas supply, there being a more or less moribund municipal gas plant and a private gas company in the field, the latter receiving its supply from a plant of by-product coke ovens, and because the price of gas, as recently established by the private company is, with one or two unimportant exceptions, the lowest general price for straight manufactured gas prevailing in North America. A circular under date of May 29 has been issued by the private company, the Hamilton Gas & Electric Co., announcing that after June 1, 1907, the price of gas generally distributed to its customers for light, heat and power will be 60 cents per thousand cubic feet, if the discount for prompt payment of bills is taken advantage of. There are other cities of about the same size in which the published minimum rate for fuel gas, presumably to the larger consumers, is 60 cents, or even less, but the price for illuminating gas is considerably higher in these cases, though coming from the same company, and presumably the same gas. There are also cities where a mixture of natural and manufactured gas is sold at something less than 60 cents, and there are many cities and towns where the price of natural gas is from 18 cents upwards per thousand feet. Even in the face of competition with natural gas, however, and in larger cities, as in Pittsburgh, Pa., Cleveland, Cincinnati, Columbus, Toledo and Dayton, Ohio, Louisville, Ky., and Indianapolis, Ind., the average price of manufactured gas, according to the published schedules, is higher than it is now in Hamilton.

The incidents that have led up to this state of affairs are interesting and instructive: In 1888 the private company, then known as the Hamilton Gas, Light & Coke Co., although having an auxiliary electric lighting department, supplied gas to the city at the stated rate of $2 per thousand. This rate caused discontent, and a municipal gas plant was established, which came into operation in May, 1890, supplying gas at the rate of $1 per thousand, for light and fuel purposes. To pay for this plant a bond issue of $150,000, bearing interest at 5 per cent. was voted. At this time the population of the city was about 12,000.

With the municipal plant in the field, the business of the private company was at first very much reduced. Where there had been 1,500 meters in operation, the number was reduced to 300. The reduction in the price of gas was met, however, and in the course of competition the price of gas reached 80 cents per thousand feet, at which figure it has been sold by both parties for several years past. The municipal plant, however, proved no exception to the rule that practice, if not theory, has established. Barely sufficient in capacity when first installed, tardily enlarged, constantly overworked, and with its proper maintenance subject to the vicissitudes of political control, it appears to have steadily gone down hill. The private company continued operations, and, in 1901, built and placed in operation a plant of 50 Otto-Hoffmann by-product coke ovens. These produced coke for domestic and foundry purposes for the local trade, and, besides the tar and ammonia also recovered, afforded an ample supply of illuminating gas for the needs of the city. In 1905, according to Brown's Directory of American Gas Companies, the private company, now called the Hamilton Gas & Electric Co., had 2,800 meters, with an output of about 82,000,000 cu. ft. per year, while the municipal plant had the same number of meters, with an output of 73,000,000 cu. ft.

Early in 1906 the State Examiner of the Bureau of Inspection and Supervision of Public Offices, Mr. L. B. Cook, having investigated the condition of the municipal undertaking, reported to the State Auditor, Mr. W. B. Guilbert, that the plant had been operated in a manner far from economical, and that the cost of gas production had at times exceeded the schedule rate charged for the service. It was further charged that the coal purchased was either delivered under-weight or that the product had been disposed of without a corresponding return to the company, that the records of sale of gas were incomplete, that there were $35,000 worth of uncollected accounts on the books on which little if any effort had been made to realize, and that, generally speaking, its affairs were in a chaotic state. Under these conditions, it was considered best to close down the plant, which was done on May 17, 1906. It continued to supply its customers, however, purchasing gas for that purpose from the rival plant at the rate of 35 cents per thousand feet, delivered in the gas-holder. It is stated, however, that no definite agreement existed, the gas being supplied daily on notification by the municipal plant to the private company that an emergency existed requiring the supply of gas for that day. According to Brown's Directory, the gas output and number of meters installed were the same in 1906 as in 1905 for the municipal plant, but the private company had increased its annual output to 100,000,000 cu. ft., with 3,100 meters installed. The price of gas, as reported, was from 80 to 60 cents, the lower price being presumably limited to large consumers.

This was the state of affairs when the circular mentioned in the first paragraph was issued by the Hamilton Gas & Electric Co. The circular, however, went further, and stated that the rate of 60 cents per thousand was to apply not only to consumers of small as well as large amounts, but also the municipal gas works' requirements, hitherto supplied at 35 cents. The municipality is therefore placed in the position of having to decide whether it will continue the purchase of gas at the higher rate, and sell or lease the remains of the municipal plant for what they will bring, or whether it will spend the money necessary to re-habilitate the plant and enter into competition with the private company. Of the original bond issue for the gas plant $115,000 was still outstanding when the plant was closed down. An additional $65,000 was voted some time ago to make the needed repairs, but there was then a prospect of leasing the works to a natural gas company, who would supply the city, so action was postponed. Nothing came of these negotiations at that time, as the natural gas supply was sold to Cincinnati instead.

The sentiment of the local press seems in favor of repairing the old gas works and resuming the manufacture and supply of gas, although the prospect does not seem over-bright. The private company has apparently been able to maintain itself profitably while selling one-half to three-fifths of the gas consumed at 80 cents, and while it avers that the supplying of gas to the municipal plant at 35 cents was done at a loss, the deficit can hardly have been such as to impair its resources, particularly as the gas from the coke ovens is to some extent a by-product, and is made whether needed or not, if the coke is in demand. Furthermore, the project of doubling the capacity of the coke plant by the addition of another fifty ovens has been stated to be under consideration, in order to supply coke to a blast furnace now building near the plant. In case this is done, there will be an additional supply of gas to dispose of from the by-product coke ovens.

That illuminating gas from by-product coke ovens is to be sold in Hamilton at 60 cents per thousand does not necessarily show that this is the price at which other cities may count upon obtaining a similar supply. It is altogether likely that the price in this case is fixed with regard to the competition to be encountered, and should be regarded in this light. It is significant, however, that a town of such relatively small size should have been able to obtain its gas supply for years past at a price usually confined to cities of three or four times its size, and under conditions not entirely favorable to economical production, by reason of the division of the field, and then to succeed to a period of still lower prices. But for the burden of the apparently ill-advised municipal gas undertaking, the unfortunate outcome of which in open competition is not fairly to be laid to the private company's doors, the city could well be congratulated on this branch of its public utilities. Certainly the circumstances in question furnish food for thought for other and larger cities, particularly those who have to pay higher prices for their gas.

Notes and Comments.

The Consolidation of State Commissions is strongly recommended in a message sent to the New Jersey legislature on June 18, by Governor Stokes. A typical consolidation is that of the State Sewerage Commission and the Passaic Valley Sewerage Commission with a reorganized State Board of Health. This is an excellent suggestion, for the State control of sewerage works is primarily a sanitary measure, like the State control of water supplies. A single commission ought to be able to accomplish more and better work with the sums now appropriated for three independent commissions, and there will be no division of authority.

The English Channel Ferry, which, as was pointed out in a communication in this journal April 13, is a matter of considerable interest in America, is now in course of becoming an accomplished fact. It has been arranged that at first only freight and night passenger traffic shall be taken, the very efficient turbine steamers at present in use being continued for the day passenger service. It is stated that the original proposal for an elevator to lift and lower the trains from boat to quay and vice versa, is to be abandoned in favor of an inclined plane worked by hydraulic power. After the ferry is established, transatlantic steamers calling at Dover will have the same advantage as if two ports, one on each side of the channel, were touched, for passengers and freight landed there will not require further transhipment whether their destination be British or continental, and the dues of only one port will be payable, not to speak of the saving in time which will be effected.

The Tehuantepec National Ry., described eslsewhere in this issue, is interesting as one of the great Mexican undertakings which the American Society of Civil Engineers has been invited to inspect during its convention and also because of its anticipated influence on the Panama Canal traffic. The location of future commercial routes is a most difficult thing to foresee and is determined by so many natural and artificial conditions, many of them constantly changing in importance, that there are many reasons for regarding the Tehuantepec Ry. as a strong rival of the Panama Canal. The road is now in a position to handle a large amount of business and its energetic and experienced managers will shortly give the directors of our own Panama Ry. a taste of competition. The Tehuantepec Ry. offers a route between New Orleans and San Francisco 1,400 nautical miles shorter than that by way of Panama and averaging perhaps 1,200 miles shorter between European and Pacific ports. The managers of the road have at least eight years to attract business before the canal can be opened, and in that time it is by no means impossible that they can intrench their 190-mile line so firmly in the favor of shippers that the canal will have to wait a long time before it receives the business prophesied by some of its advocates, who have overlooked the advantages of the Tehuantepec route and the combined resources of the Mexican government and the great interests behind Sir Weetman Pearson.

A Verdict for $101,000 has been returned against the New York Central & Hudson River R. R., in favor of a woman whose husband was killed in an accident at Van Cortlandt Park in June, 1904. An automobile in which he was riding was struck by an engine, the approach of which was concealed by a train standing at the station. The testimony showed that the warning bell at this crossing was out of order and failed to give notice of the engine's approach. A verdict of $30,000 was recently awarded to a young woman who was also riding in the automobile at the time and lost a leg, and a verdict of $10,000 was awarded to the chauffeur who was similarly injured at the same time. Attention is called to these large damages because they are a manifestation of the rapidly growing belief that the only way to insure safety against railroad accidents of all sorts is to assess the utmost legal penalty against those responsible for them. While such a plan will unquestionably work with great severity against railroad companies in comparison with the former custom, there can be no question about its being favorably received by the public, even by the large proportion of it which does not believe in the indiscriminate legislation regarding rates which now finds favor. The general argument made in favor of awarding such high damages in cases of preventable accidents is that unless they are imposed the discipline on railroads will remain as lax as it is now, and the safety of railway travel cannot be increased. If such damages become the rule, it will not be long, it is believed, before the railroad companies will secure the passage of laws imposing equally severe penalties on employes who are in any way negligent in duties affecting the security of transportation.

The Tar-Spreading Machine Competition recently held in Great Britain demonstrated the great diversity of opinion regarding the best method of applying tar to roads. It is generally recognized that certain preparations of tar can be used to advantage in preventing dust on some roads, but sufficient experience has not yet been had to give a clear understanding of the limitations of the usefulness of such applications or the methods best suited for different types of roads. If such definite information were available, it is hardly likely some manufacturers would have entered in this competition machines which allowed the tar to pour over the roadway, while others submitted machines which distributed the tar in a fine spray not only over the ground, but also over the wayside trees, so that it resembled a Scotch mist. Some machines ejected the tar under pressure and others allowed it to flow by gravity; some of them soaked the roads and others merely dampened them. In due course a report on the competition will be made by the judges of the Road Improvement Association, and probably will settle some of the questions regarding tarring that are now in dispute. It is safe to say, however, that if American experience with road oiling affords any criterion for estimating future experience with tar applications, knowledge of the subject will not be materially increased until those in charge of the experiments record all facts concerning the character of the tar used, the nature of the roads, the method of tarring and weather conditions during the progress of the work, and the nature of the traffic and the weather conditions after the treatment of the surface. The subject is seemingly simple, but actually it includes so many factors that at the present time it is impossible to know just which are most important. This knowledge will only come from experience, which makes it particularly desirable for all engineers who conduct tarring experiments to publish the results of their observations. Otherwise there will be a great and unnecessary waste of time and money in an endeavor to accomplish dust-laying by imperfect methods.

The Erection of Two Large Buildings in New York, one of steel and the other of reinforced concrete, is described in two articles in this issue, to which special attention is called. Taken together they explain fairly well the great change in ordinary building methods made necessary by the use of reinforced concrete skeletons. One building was erected by a company which has long been noted for the rapidity with which it can do work when speed is desirable, and the explanation of the steps it took in constructing the Trust Company of America Building gives an outline of what may be called standard structural steel erection. The Salvation Army Building was constructed by a company that has been making a special study of methods of building reinforced concrete structures. It recognized that it was much more expensive to manufacture materials on the building site, as is done when concrete is used, than in the steel shops and the tile yards, as is the case with steel-cage structures. Accordingly, it developed a system of self-supporting reinforcement that goes together something like the frame of a steel building and permits rapid erection. The methods employed on this building are particularly interesting on account of their novelty, and the statements of costs, furnished by the contractor, are decidedly instructive. It should be pointed out, however, that one feature of concrete construction is not mentioned in the article, which does not lay emphasis on the great importance of providing in advance for all the minor work which must be done after columns and floors are completed. There is nothing gained by running up a concrete structure in a short time and then wasting time in laboriously cutting holes in the concrete for pipes and wires. In a building of some height the delay incident to drilling holes in the concrete to secure the nailing strips for the flooring may mean the loss of a week. The finishing of the concrete surfaces, particularly those on the street fronts, takes a surprising amount of time at present. These and other features of concrete building construction are mentioned to show that both the architect and the engineer must modify the methods which have become standardized for steel and tile construction when they employ concrete, if the same degree of economy is to be attained with the latter as with the former.

THE TEHUANTEPEC NATIONAL RAILWAY.

In January of this year inter-ocean traffic was inaugurated on the reconstructed Tehuantepec National Ry. which connects Puerto Mexico, formerly called Coatzacoalcos, on the Gulf of Mexico with Salina Cruz on the Pacific Ocean. The advantages offered by the Isthmus of Tehuantepec as a commercial highway have attracted much attention since the early part of the last century, and numerous roads and railways have been projected under concessions from the Mexican government. None of these plans, however, was executed, and after revoking the concessions, the government in 1882 decided to construct the railway and entered into a contract which, after 67 miles of line had been built, was rescinded in 1888. Between 1888 and 1894, the date of the completion of the original road, work was carried on by three different contractors. It was no sooner declared finished than it was found to be inadequate to handle the heavy traffic for which it was intended and the harbor facilities at both ends of the line proved insufficient for economical operation.

Realizing that the work would have to be done on a much broader scale in order to attract the traffic which it was hoped would make the enterprise a most important factor in the world's commerce, the Mexican government opened negotiations with S. Pearson & Son, Ltd., who had already constructed drainage and harbor works in Mexico, and were therefore familiar with the climatic and labor conditions. The negotiations resulted, in 1898, in the conclusion of a contract between the government and the company for the reconstruction of the line and the building of extensive harbor works at both termini. This contract has been modified from time to time and under the present agreement the Mexican government and S. Pearson & Son, Ltd., are partners in exploiting the railroad and the ports. This agreement is for 51 years, commencing July 1, 1902, and provides for the payment of operating expenses, maintenance cost, interest on bonds, and on the capital invested by the two partners, and for the establishment of a sinking fund to improve the port at the Gulf terminus. The surplus after these payments have been deducted from the gross income is to be divided between the government and the contractors, the government receiving 65 per cent. for the first 36 years, and 68½, 72½ and 76½ per cent. respectively during three following periods of five years each. The firm acts as manager of the property, and the government retains the right of inspecting material and the administrative and financial records of the railway and port works, and passing on plans for additions and improvements. At the expiration of the contract, the railway and port works are to become the sole property of the government.

The work done on the railroad up to 1894, including much reconstruction, cost about $14,000,000 (American) and the amount since expended in bringing it up to its present condition is about $7,500,000. The work done since 1899 involved the reconstruction of the line on standards suitable for the heavy traffic which it is to carry, and included the widening and improvement of the roadbed, the substitution of heavier rails, and the renewal of bridges, trestles and culverts.

The length of the railroad is about 190 miles, though the width of the Isthmus is only 125 miles. For the first 99 miles from the gulf the line traverses a broad plain offering no special engineering difficulties, the maximum curvature being 11.6 deg. and the maximum grade 1.6 per cent. The next 56 miles embrace the crossing of the Cordilleras, where the road rises near Lagunas to an elevation of 262 meters, about 860 ft., above sea level, and then descends to the Pacific coast, the descent being more abrupt than the rise on the gulf side of the range. The last 35 miles crossing the Pacific plain resemble in most features the corresponding plain on the north or Atlantic side of the mountains. On the most difficult part of the work, in Chivela Pass, the maximum grade is 2.7 per cent., and the maximum curvature 21.8 deg., and there are two horseshoe curves and a tunnel, 230 ft. long.

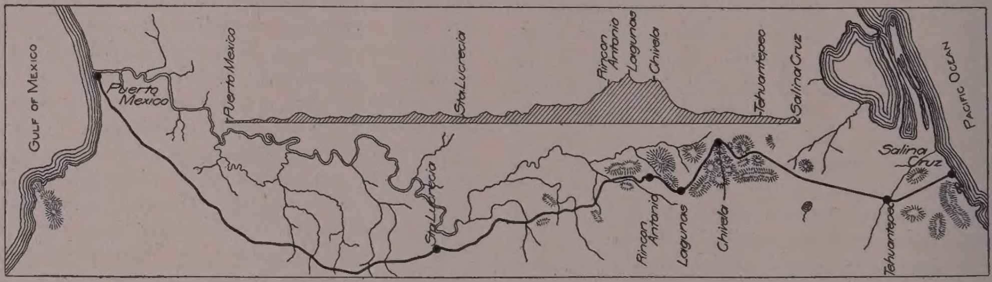
The road is of standard gauge and is operated with a single track, but allowances for double tracking have been made, and should the traffic prove equal to expectations this will undoubtedly be carried out. Both rock and gravel are used for ballast, and in many places on the north side of the mountain range ballasting to a depth of 5 ft. was necessary on account of subsidence into the soft alluvial soil. The original road was laid with 56-lb. rails, but in reconstruction 80-lb. rail was substituted and has been placed on 151 of the total 190 miles. The ties, which are of creosoted pine, native hardwood and California redwood, have all been renewed since 1898 and most of them provided with tie plates.

The grades and curves on the original road were far in excess of what was permissible for the efficient handling of inter-oceanic traffic, and much heavy work has been done to reduce these to the maximum values previously stated. Relocations have been made in some places involving the abandonment of much work done for the original line, and the resulting alignment and grades in many sections allow a speed of 50 to 60 miles per hour. The number of small streams which discharge large volumes of water during the rainy season, particularly on the north side of the mountains, has caused a heavy outlay for bridges and culverts. The original bridges were inadequate for the heavier rolling stock and loads to be carried on the new road, and have been replaced by more suitable structures, and the former timber culverts have been replaced by masonry arches and boxes, and drain pipes. There are in all 862 waterways across the track of which number 225 are spanned by steel trusses, plate girders and trestles, and 163 by masonry arches, the remaining crossings being in boxes and pipes. The longest span, the central one of the Tehuantepec River crossing, is 204 ft. The masonry on the northern division, where rains prevail for the greater part of the year, is chiefly cement concrete, and on the southern division rubble.

The luxuriant vegetation has proved a costly maintenance problem, and in addition to the constant use of manual labor for removing grasses and weeds which would soon hinder traffic, oiling the roadbed is practiced. The equipment for the latter work consists of a tank holding about 6,600 gal., with suitable spraying devices and an apparatus for heating the crude oil. The latter is heated to 210° F., and the roadbed is gone over twice, about 500 gal. being used per kilometer each time, or a total of 1,000 gal. per kilometer. Within four days after the final spreading all the weeds are found killed, whereas the growth is checked only temporarily by the older manual method. The cost of twice spreading the oil is $80 per kilometer, while the cost of hand labor for keeping down the weeds for a year is $90 for the same distance, making a saving of $10 per kilometer, two oilings being effective for about a year. The oil is obtained from a field which S. Pearson & Son have opened on the Coachapa River not far from the railroad.

The management has calculated the capacity of the road to be ten 300-ton freight trains in each direction every 24 hours. The freight schedule from ocean to ocean is 12 hours, and the harbor facilities have been planned so that the cargo of a vessel of the size expected to call at the two termini, can be unloaded and transferred across the isthmus within 30 hours after the arrival of the vessel.

The railroad has one branch 18 miles long extending from Juile on the main line to San Juan Evangelista, and connection is made with the other Mexican railroads through the Vera Cruz & Pacific R. R., thus giving access to Mexico City and all parts of the country as well as to the railroads of the United States. The junction is at Santa Lucrecia. The Pan-American line, which it is proposed to extend through Central America taps the Tehuantepec road at San Geronimo, near the Pacific coast.

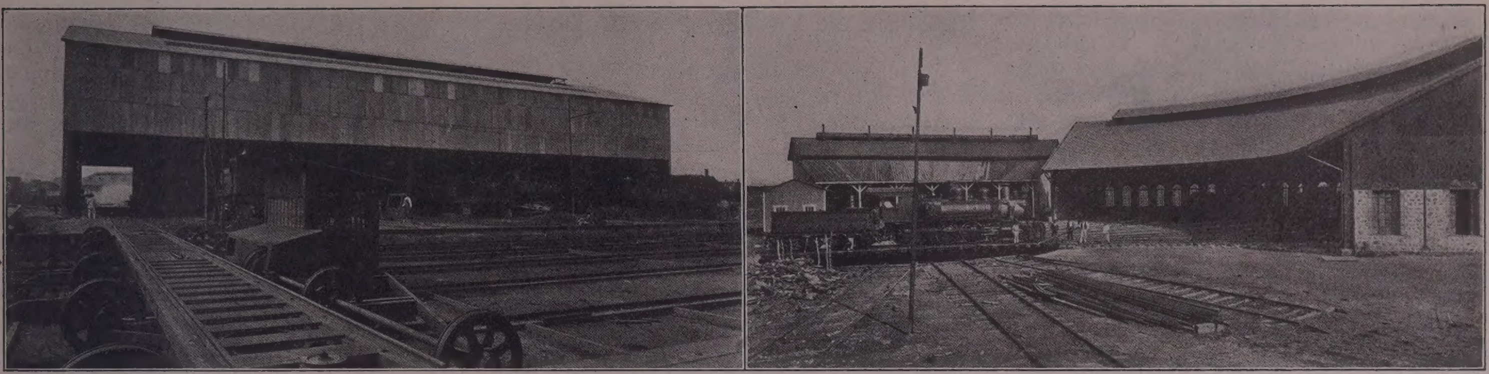


Map and Profile of the Tehuantepec National Railway.

The bulk of the rolling stock was built in the United States and compares favorably with that in use on American roads. There are now in use, or ready, on the isthmus, 40 locomotives, 35 passenger coaches, 1,250 box cars, 120 flat cars, 60 stock cars, and about 50 cars for miscellaneous purposes, and orders now standing will increase the equipment 20 per cent. The roofs of the box cars are so constructed that one-half can be pulled back so that they can be loaded directly by the electric traveling cranes which lift the freight out of the holds of the vessels.

All the locomotives burn oil, and the experience with this fuel lasting over a period of three years has shown it to be entirely satisfactory and economical. The oil now used is brought from the Beaumont, Tex., field by tank steamers having a capacity of 6,000 tons each, and is unloaded and stored at Puerto Mexico. There are four storage tanks at different points on the line each having a capacity of 28,000 gal. Within a short time, however, it is expected that the road will be entirely independent of this supply and will utilize the oil obtained from the field at San Cristobal on the Coachapa River. A pipe line has been laid from San Cristobal, a distance of 20 miles, to Minatitlan, where a refinery is being erected, and from this point a branch railroad will be built meeting the main line about 18 miles from Puerto Mexico. The use of oil fuel, besides being economical, has the advantage of freedom from smoke and soot, conducing much to the comfort of passengers.

The general offices, shops, store houses, and hospital are located at Rincon Antonio, 125 miles from Puerto Mexico, and 65 miles from Salina Cruz, the Pacific terminus, at an elevation of 600 ft. above sea level. The climate is moderate,



Locomotive Repair Shop and Roundhouse, Rincon Antonio.

owing to the winds which blow almost constantly from one ocean to the other, and there is but little rain as compared with that falling on the plains skirting the Gulf coast. The town site is entirely owned by the railroad company and was selected on account of its climatic and geographical advantages as the headquarters for the officials of the road.

Machine and carpenter shops, a foundry, and car and locomotive repair shops, have been fitted up with English and American machinery and are now in operation. All of the machines are driven by individual motors supplied with current from a central station, the boilers of which are fired with oil fuel. The car and locomotive shops are in parallel buildings between which is an electrically-operated transfer table. Store houses for all materials used by the company, and a ten-stall engine roundhouse, are located conveniently to the shop buildings. The power house is built of stone, and the shop buildings have wooden and steel frames covered with corrugated galvanized iron. The officials of the company are housed in attractive frame cottages, as are the higher class of employees, and the mechanics and laborers in rows of buildings divided into dwellings each containing six rooms and bath. The town is lighted by electricity, supplied with running water of excellent quality, and has a sewerage system. The water is obtained from a spring near by and stored in a concrete reservoir from which it flows to a large tank, designed to furnish an ample supply by gravity for the usual consumption and for fire protection.

The company has endeavored to make living in Rincon Antonio as agreeable as possible, and in addition to giving special attention to providing comfortable and sanitary homes for employees, has erected a large club house, a church and a meeting hall.

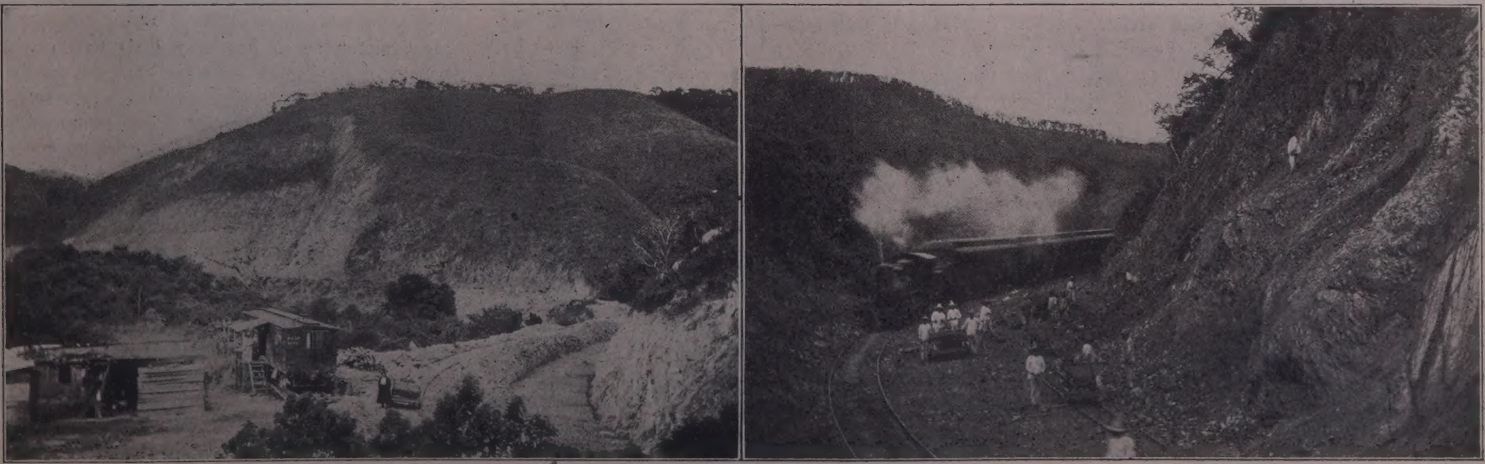
The work at each terminal has been of a very extensive nature and includes the building of a safe and adequate harbor, and wharfage and storage facilities commensurate with the traffic which it is expected to handle. The work at Salina Cruz, the Pacific terminus, was by far the more difficult, there being no bay, river mouth, or other natural feature favorable to the construction of a harbor. It was necessary to convert an open roadstead into a safe port, and this has been done by the formation of two harbors, the outer one protected by two breakwaters with a total length of 5,404 ft., and containing 974,000 cubic meters of rubble and concrete block filing. This work has been fully described in The Engineering Record of March 30, of this year. The construction of the inner harbor, which measures 820 by 3,380 ft., requires the dredging of 4,000,000 cu. yd. of material in order to obtain a depth of 33 ft. at low tide. Six steel-frame warehouses, flanked by railroad tracks, are located on the quays, and these facilities will eventually be supplemented by the construction of ten wharves, for which allowance has been made in the design of the works. A dry dock measuring 100 x 675 ft., with a depth of 36½ ft. on the sill, is also in course of construction.

At Puerto Mexico the harbor problem proved easier than at Salina Cruz. The Coatzacoalcos River afforded a good harbor, its depth being about 50 ft. and its width 2,000 ft., but a bar had formed across the mouth over which the depth at low tide was only 14 ft. The harbor problem therefore, was the construction and maintenance of a channel through this bar, and this has been accomplished by building jetties converging seaward at an angle of 35½ deg. and confining the river between them. Their distance apart at the shore ends is about 3,400 ft. and at the seaward ends about 656 ft., and the confinement of the flow of the river within this comparatively narrow channel has resulted in scouring out the bar to the desired depth of 33 ft. The original scouring did not proceed as rapidly as was wished, and two dredges were used for a time to hasten the work. Both jetties are over 4,000 ft. long. They are composed of rock weighing from 25 lb. to 2½ tons, covering which is a layer of rock composed of masses weighing not less than 2 tons each, and on the seaward ends of the jetties an additional layer of molded concrete blocks, weighing from 20 to 40 tons, has been placed.

The arrangements for handling freight at Puerto Mexico are fully equal to those at Salina Cruz. There are eight steel wharves which will be accessible even at low tide to vessels drawing 33 ft., and on each wharf is a steel frame warehouse 108 ft. wide and 408 ft. long. Railroad tracks of standard gauge are laid between the edge of the wharf and the warehouse, and these are spanned by electric cranes which have a reach of 86 ft., sufficient to unload the cargoes directly from the vessels into the warehouse or the cars. The cars and warehouses have hatched roofs in order to allow the crane to deposit freight in them directly.

Ample yards have been provided at both terminals for the storage and handling of cars, the cleaning and housing of locomotives, and for rapid switching to and from the warehouses. A power house at each end supplies the current for the electric cranes and hoists. The cities at both terminals have not only been benefited by the influx of artisans and the increase in business due to the work of the railroad company, but have been improved in sanitary conditions. The old town of Salina Cruz was abandoned owing to the encroachment of the harbor work, and a new town laid out on modern lines was built at a higher elevation. The former town of Coatzacoalcos, now called Puerto Mexico, has been overhauled and put on a good sanitary basis, and the fever-breeding swamps near the town have been filled up.

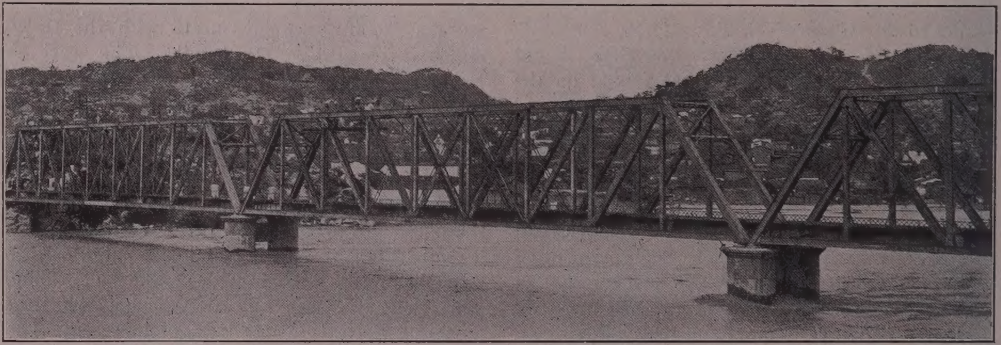
The main object of the railroad is to transfer cargoes from vessels on the Gulf of Mexico to vessels on the Pacific Ocean, thereby saving the trip around Cape Horn or through the Straits of Magellan, and rivalling the Panama Canal as an inter-oceanic highway. While the construction



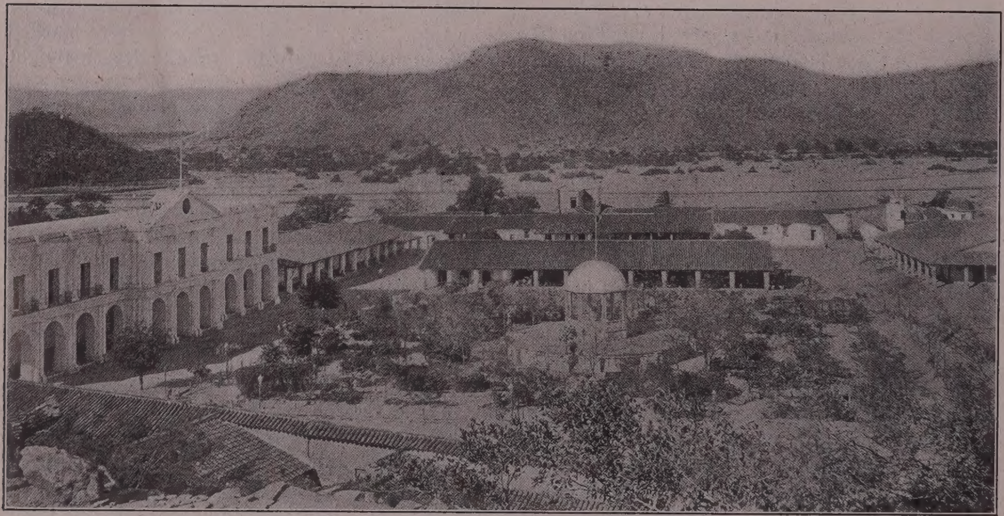
Grade Reduction and Roadbed Improvements during Reconstruction.

has been in progress, the management has not neglected the commercial side of the undertaking, and has already secured the traffic of one steamship route which heretofore operated via the Straits of Magellan. The line referred to is the Hawaiian Steamship Co., which is in the sugar transportation trade between Hawaii and New York; and also touches at Far Eastern ports. The new service via the Tehuantepee Ry. was inaugurated in January of this year. Puerto Mexico is now a regular port of call for five other steamship companies operating between the United States and Mexican and South American ports, and Salina Cruz has a regular service of three lines besides the Hawaiian Steamship Co. The advantage claimed for the Tehuantepec Ry. over the Panama Canal is that the routes between practically all of the large trade centers are shorter by the former from 1,000 to 1,800 miles, a saving of from 4 to 7 days in time, taking the average speed of freight steamers to be about 250 miles per day, and making the freight rates between these ports less by the railroad via Panama. It is understood that the management expects to handle about 600,000 tons of freight in 1907, and has about 1,000,000 tons in sight for 1908.

The total expenditure on the undertaking will probably reach $65,000,000, this amount including the $14,000,000 expended on the railroad proper before the present constructors became interested in the project.



Bridge Over the Tehuantepec River.



Plaza in the City of Tehuantepec.

All of the work is being done by S. Pearson & Son, Ltd., of which firm Sir Weetman Pearson is the head. The affairs of the firm on the Isthmus of Tehuantepec are in the hands of Mr. J. B. Body, as resident director. Mr. J. N. Galbraith is general manager, and Mr. D. C. Coe, who furnished the data for this article, is chief engineer of the railway. Mr. Leandro Fernandez, Minister of Public Works, of Mexico and president of the Mexican Society of Engineers and Architects, represents the government in the administrative affairs of the railway.

Turbine Economy Records of an unusual character have been made by the 1,500 and 5,000 A. E. G. units in the stations of the Berlin Electricity Works. At the Moabit station, of this company, a record of 6.7 kg. of steam per kilowatt-hour has been made by Sulzer reciprocating engines using steam at 300° C. Recently the small and large turbines have run at 6.7 kg. and 6 kg., respectively, with steam at the temperature mentioned, and the large turbine is estimated to have run at 5.5 kg. with steam at 350°. These figures include allowances for steam used for excitation and condensing purposes.

High-Duty and Low-Duty Pumping Engines.

In ordinary water-works service where more than 5,000,000 gal. must be pumped daily, there are comparatively few cases where a high-duty pumping engine is not preferable, but where the capacity is from about 3,000,000 to about 5,000,000 gal., the choice between high-duty and low-duty types is often somewhat perplexing. While no rules can be laid down for every case, a great deal of valuable information regarding the more important points to be considered in making such a choice were given in a paper on the subject prepared by Mr. Irving H. Reynolds, the eminent pumping-engine designer, for the Toronto convention of the American Water Works Association. The discussion does not include centrifugal pumps, air lifts or direct-acting pumps with high-duty attachments, although many of the figures are applicable to any type of machinery of a given economy.

Of course all types are not equally suitable for every location, and whether the engine is to be horizontal or vertical, compound or triple expansion, must necessarily be determined by local conditions. Horizontal engines naturally cost much less than vertical, and in the small sizes under consideration are perhaps equally satisfactory. Speaking of the proposition as a whole, Mr. Reynolds says that all large engines should be of the vertical type with single acting plungers, and should preferably be of the triple expansion type. All direct-acting engines should be of the horizontal type, in his opinion, and all pump plungers should be outside packed, except for very light pressure with clean water.

In guaranteeing duties, engine builders commonly used 1,000 lb. of dry steam as the basis, and it is quite proper to do so for several reasons, because it gives a practically uniform standard for comparison, it eliminates the question of variation in quality of fuel, skill of firemen, and other factors over which the engine contractor, as a rule has no control, and therefore puts the pumping engine proper on its own merits, yet as the purchaser is primarily interested in the cost of operation, fuel must necessarily enter into his calculations.

In arriving at a choice, two main points are to be considered, i. e., first cost and cost of operation.

Under the first item, are properly included the cost of the engine foundations, boilers, buildings, etc., and under the second item, fuel, supplies, attendance, depreciation and repairs. In arriving at the first cost, it may be safely assumed that the cost of foundations, buildings, etc., would be substantially the same for either type of engine, but the capacity of boilers required is proportional to the duty, and therefore the increased cost of boilers is properly chargeable to the lower duty machines, so that the item of first cost should include both the engine and boilers.

Under the cost of operation, the most important is that of fuel, and in engines of the comparatively small size under consideration, this may be taken as the only point of difference between the two types. While doubtless arguments will be made over the relative cost of attendance, supplies, depreciation and repairs, yet experience has failed to show any measureable difference, except in the larger sizes of vertical high-duty machines where the cost of maintenance has reached a remarkably low figure. Under all circumstances these items for the high-duty engine may be safely assumed at least as low as for the low-duty machinery, although for the purpose of simplifying the calculations, Mr. Reynolds has assumed that in all types of engines, the depreciation and repair account is a certain percentage of the first cost. This is not strictly true, particularly when high speeds are entered into; the depreciation and repair account being almost in direct proportion to the number of strokes per minute of the engine.

Mere piston speed has very little to do with the wear of machinery, he states, but the number of reversals in a given time determines the wear; this bearing particularly on the life of pump valves and wear of journals and pins, so that an engine of short stroke and high revolutions will have a much higher depreciation account than one of longer stroke and slower revolutions, although perhaps operated at a higher piston speed.

The question of the lower duty shown under every day working conditions as compared with that of official tests, is a matter which, for the purpose of this paper, must be considered as practically the same for any type of engine, although as a matter of fact, Mr. Reynolds believes that the falling off in duty of direct-acting pumps is greater than that of the flywheel machines, due principally to the failure of the direct-acting engines to make their full strokes unless the cushion

Table Showing Comparative Cost of Operation of 5,000,000-Gal. Pumps of Different Types Against 240-Ft. Head.

Type.	Price.	Guaranteed Steam Duty.	Extra Boilers.	Fixed Charge.	Annual Coal Duty.	Annual Coal.
A	$30,000	150 million	......	$3,000	110 million	1,655 tons
B	$20,000	125 "	$460	$2,046	95 "	1,911 "
C	$12,000	95 "	$1,400	$1,340	70 "	2,604 "
D	$10,000	80 "	$2,160	$1,216	60 "	3,032 "
E	$8,000	65 "	$3,130	$1,113	50 "	3,633 "

Coal per ton	$1.00	$1.50	$2.00	$2.50	$3.00	$3.50	$4.00	$4.50
Cost of Type A, Triple-Expansion Flywheel Pump.								
Fixed charge	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
Cost of coal	$1,655	$2,482	$3,310	$4,137	$4,964	$5,792	$6,619	$7,446
Total cost	$4,655	$5,482	$6,310	$7,137	$7,964	$8,792	$9,619	$10,446
Cost of Type B, Compound Flywheel Type.								
Fixed charge	$2,046	$2,046	$2,046	$2,046	$2,046	$2,046	$2,046	$2,046
Cost of coal	$1,911	$2,867	$3,837	$4,778	$5,733	$6,689	$7,644	$8,600
Total cost	$3,957	$4,913	$5,868	$6,824	$7,779	$8,735	$9,690	$10,646
Cost of Type C, Triple-Expansion Direct-Aacting Duplex.								
Fixed charge	$1,340	$1,340	$1,340	$1,340	$1,340	$1,340	$1,340	$1,340
Cost of coal	$2,604	$3,906	$5,208	$6,510	$7,812	$9,114	$10,416	$11,718
Total cost	$3,944	$5,246	$6,548	$7,850	$9,152	$10,454	$10,756	$13,058
Cost of Type D, Compound Direct-Acting Duplex.								
Fixed charge	$1,216	$1,216	$1,216	$1,216	$1,216	$1,216	$1,216	$1,216
Cost of coal	$3,032	$4,549	$6,065	$7,581	$9,097	$10,613	$12,130	$13,646
Total cost	$4,248	$5,765	$7,281	$8,797	$10,313	$11,829	$13,346	$14,862
Cost of Type E, Compound Direct-Acting Duplex.								
Fixed charge	$1,113	$1,113	$1,113	$1,113	$1,113	$1,113	$1,113	$1,113
Cost of coal	$3,633	$5,450	$7,266	$9,083	$10,899	$12,716	$14,532	$16,349
Total cost	$4,746	$6,563	$8,349	$10,196	$12,012	$13,829	$15,645	$17,462

valves are frequently and carefully adjusted.

The causes for the lower duty under every day conditions are many, the most common of which is carelessness on the part of the engineers in failing to operate machinery under the conditions for which it was designed. As regards the coal duty, it is practically impossible to keep the efficiency of the firemen up to anything approaching that prevailing during a test. As far as the loss in economy in the engine itself goes, the most common cause of this is the operating of the machinery against pressures very much lower than those required for the duty test, and no greater mistake can be made than to purchase machinery stipulating that the duty test shall be made against, say, 100 lb. water pressure, when the actual pressure under daily service is much lower.

The questions of capacity and strength should not be confused with that of economy, and engines should be designed to give their highest economy, and should be tested, with the steam and water pressures prevailing in ordinary service. These, however, are all matters of operation over which the engine builder has no control, and it may be safely said that the duty of every engine under service conditions is proportional to its duty under test conditions, and that a high-duty engine has the same relative higher economy over the low duty machines under all circumstances.

The cost of fuel is the item that varies most widely, and although it has been suggested that the average price of coal is such that about 100,000 B. t. u. are obtained for a cent, this can by no means be accepted as a fact, as the greatest factor in the cost of fuel is its transportation, so that coal of high heat value may be obtained at very low cost in the proximity of the mines, while perhaps in another locality coal of much inferior quality brings a higher price per ton. It being impossible to determine on a general price of coal, it is necessary in every case to make calculations based on the price and quality of the fuel at the particular location.

Mr. Reynolds has long been in search of a boiler that would evaporate 10 lb. of water per pound of coal under actual conditions in every day service, but believes that there is not a single boiler in America doing this to-day, and the boiler plants where the evaporation obtained is better than 9 lb. of water per pound of coal, can be counted on the fingers—perhaps of one hand. He believes a fair average for the better plants burning a good grade of bituminous coal is not far from 8 lb., while the majority of plants, say in the Middle West, burning a medium grade of coal, are not doing much better than 7 lb., and in a very large number of cases where slack or low grade fuel is used the evaporation is about 6 lb. The above figures are not "from and at 212° per pound of combustible," but are based on the total coal burned to the water actually evaporated into steam at boiler pressure from the normal temptation of the feed water.

In order to facilitate the calculations, instead of using gallons, it is easier to base the calculations on the water horse-power (w.-h.-p.), this being the theoretical power required to raise a given quantity of water to a certain height in 24 hours. Mr. Reynolds gives a number of useful tables of engine and boiler performance, one of which shows in a rather startling way the meaning of high and low duty. Taking, say, compound direct-acting pumps at 50,000,000 annual coal duty consuming 17.34 tons per water horsepower per year against high grade plants having duties of from 130,000,000 to 140,000,000, as at New Bedford and Boston, where the coal consumption runs from 6 to 6½ tons per water horse-power per year.

There is no definitely recognized dividing line between high and low duty, but perhaps 100,000,000 duty per 1,000 lb. of steam is now generally regarded as the division point, although not so many years ago 100,000,000 duty was considered high.

As pumping engines are special machines and to attain the best results should be built especially to suit the conditions at each location, the price of them is necessarily variable, and is not directly proportional to the economy guaranteed. As the price of the fuel varies in every case and the quality of it bears no fixed relation to its price, no unit of value can be established for it. It is these conditions that makes it necessary to consider each case by itself, and to illustrate Mr. Reynolds takes the case of an engine of 5,000,000 gal. capacity against a head of 240 ft., or a total of 210 w.-h.-p.

He assumes that five different engines are offered. Engine A is a triple expansion costing $30,000, with 150,000,000 guaranteed duty; engine B a horizontal cross compound engine costing $20,000, with a guaranteed duty of 125,000,000; engine C a horizontal triple expansion direct-acting, costing $12,000, with a duty of 95,000,000; engine D a horizontal duplex direct-acting, costing $10,000, and having a guaranteed duty of 80,000,000; engine E a horizontal direct-acting duplex, costing $8,000, with a guaranteed duty of 65,000,000. The type of engine, however, cuts no figure as he is considering only the cost and duty.

The less economical engines from B to E will require more boiler capacity than engine A; the difference in boiler horse-power required being added to the first cost of the engine at the rate of $27 per boiler horse-power.

As the duties guaranteed are on the basis of 1,000 lb. of dry steam and for test conditions only, he assumes that under every day working conditions, the engines will only give about 94 per cent. of their guaranteed steam duty, and that the evaporation of the boilers is only 8 to 1, which would bring the actual coal duty down to 75 per cent. of the guaranteed steam duty. This figure is rather a high one for most locations, and 70 per cent. or even 65 per cent. of the guaranteed steam duty would be the more common coal duty.

The cost of operation of each of these engines is made up of two items; fixed charges and coal, the fixed charges covering interest, depreciation and repair, which for the sake of convenience is taken at 10 per cent., although as a matter of fact, 8 or 9 per cent. would cover this in most cases, especially on large engines.

With coal at $1 per ton, the cost of operation of engine C is the least of all, $3,944; engine B being practically the same at $3,957. Engine A, with the highest guaranteed duty, is next to the most expensive to operate, that is, $4,655, as against the low duty engine E at $4,746.

When the cost of coal increases to about $1.30, engine A falls below engine D, and at about $1.75, engine A crosses engine C, so that at $2 per ton, engine B is the cheapest to operate, engine A next with engine C, D and E following. In fact, engine E is out of the race altogether unless the price of coal runs below $1 per ton, or unless the first cost of the engine could be reduced. The same is practically true of engine D; the race being between engines A, B, and C up to $1.75 per ton. After that, it is between A and B until a price of about $3.80 is reached, where the high duty engine A crosses B and has an increasing advantage, as the price of coal per ton increases.

All these relations would change with any change in the first cost of the engines, or with the guaranteed duty. Or, in case the engine was not worked up to its full capacity, either by being operated at slow speed or only part of the time, then the proportion of coal cost to fixed charges becomes less.

The table in which the relations are summarized shows very clearly that the low duty engine must be of very low first cost and fuel must be very cheap in order to justify its adoption. For instance, with coal at $3 per ton, there is a difference of over $4,000 in the cost of operating engines A and E, which is sufficient to pay 5 per cent. on a difference in cost of $80,000, or nearly 20 per cent. on the actual difference in cost of $22,000. With coal at $3 per ton, the difference in cost of operation between engines A and C is $1,188, or practically 12 per cent. on the $10,000 difference in first cost.

The duplex pump is a machine beautiful in its simplicity, and its inventor, Mr. Worthington, is entitled to the greatest possible credit. As a machine for handling water at moderate speeds, it left little to be desired except in the matter of economy (and at the time of its invention but little in this particular), but the building of it in the modern triple expansion form has advanced it to as high a position, Mr. Reynolds thinks, as it can ever hope to occupy while retaining its simplicity.

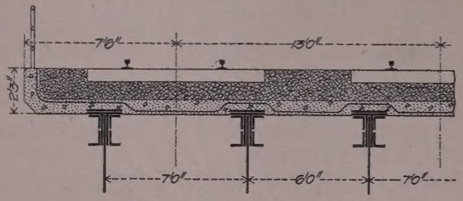
For handling small quantities of water where the item of fuel is of secondary consideration, the duplex pump, on account of its lower first cost, has the field, but there is an increasing number of small fly wheel pumps of high and medium duty being built which, together with the increasing cost of fuel will, Mr. Reynolds believes, ultimately confine the duplex pump to a still narrower field consisting of the smaller sized machines.

A Six-Track Solid-Floor Plate-Girder Bridge.

Bridge 60 on the main line division of the Delaware, Lackawanna & Western R. R. at Scranton, Pa., crosses the Lackawanna River with two spans of 115 ft. 3 in. each and two approach spans of about 62 ft. and 48½ ft. respectively, the lengths being measured on centers of piers. There are also two single-track approach spans of about 34 and 43 ft. In the substructure there are two abutments, one intermediate pier about 6 ft. wide and 42 ft. long on top, and another intermediate pier 8 ft. wide and 42 ft. long which is on much lower ground in the channel and is supplemented, to save masonry and improve appearances, by a steel tower about 25 ft. high. The superstructure consists of 12 lines of deck plate girders with fixed bearings on the steel tower and expansion bearings at all other points. At one approach all of the girders are skewed about 4 deg., and at the other approach ten girders are skewed 25 min., and two about 3 deg., the intermediate girders all being square with the abutments.

The bridge is designed in accordance with the railroad's standard bridge specifications for a live load on each track, consisting of two locomotives followed by a train load of 4,500 lb. per lineal foot. The dead load per linear foot of each girder was assumed to consist of 870 lb. of ballast, 730 lb. of concrete, 200 lb. of track and 1,500 lb. of steel for the channel spans, giving a total of 3,300 lb. In all cases the loads from the adjacent ends of two girders in successive spans take bearing on the same pedestal. In one of the channel spans this produces a reaction for a single line of girders of 521,750 lb., which, at the maximum unit pressure of 250 lb., requires 2,087 sq. in. of bearing surface on the concrete. The maximum pressure was at the foot of the steel tower, where the reaction for each girder amounts to 435,066 lb., and is distributed over an area of about 24 sq. ft. by heavy cast-iron pedestals.

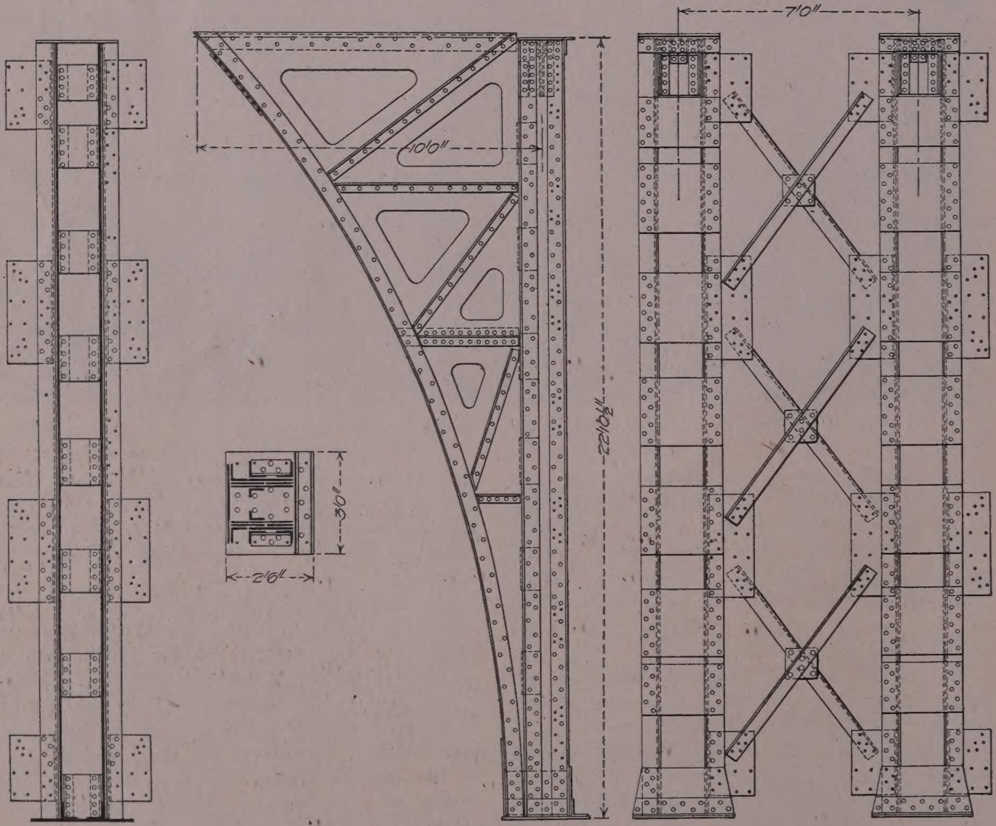
The channel span girders are 116½ ft. long over all and have pin bearings 113 ft. 4½ in. apart on centers. The assumed loading produces a maximum shear of 389,520 lb. and a total moment of 10,312,590 ft.-lb. To reduce the shear to a web pressure of 6,000 lb., the web plates are required to have a cross-section of about 65 sq. in., and are made in the end panels of 114x¾-in. plates having a gross section of 85½ sq. in. and a net section of 66 sq. in. The intermediate web plates have a thickness of 11-16 in. and are stiffened by pairs of vertical 5x3½x⅜-in. angles. The bending moment divided by 9,900, multiplied by 8.84, gives 117.84 sq. in. required net cross-section for each flange. This is built of four 8x8x⅞-in. angles two 17x⅝-in. side plates and four 20x¾-in. cover plates, the latter varying from 42½ ft. to full length, and all of them aggregating 118.67 sq. in. of net cross-section.



Solid Floor Construction.

The six tracks are spaced 13 ft. apart on centers, and the two girders for each track are spaced 7 ft. apart and connected by transverse struts and zigzag angle bracing in the planes of the top and bottom flanges, the systems being arranged so as to intersect in each panel. In the top flange plane only, the zig-zag bracing is continued between adjacent pairs of girders so as to provide for a continuous transmission of lateral stresses from one side of the bridge to the other. Over the river piers, the girders in adjacent spans are separate from each other but are both fixed to the same steel tower; over all other piers the ends of adjacent girders are rigidly connected so as to make them continuous.

Erecting Girders with Derrick Cars.



Details of Tower on Pier.

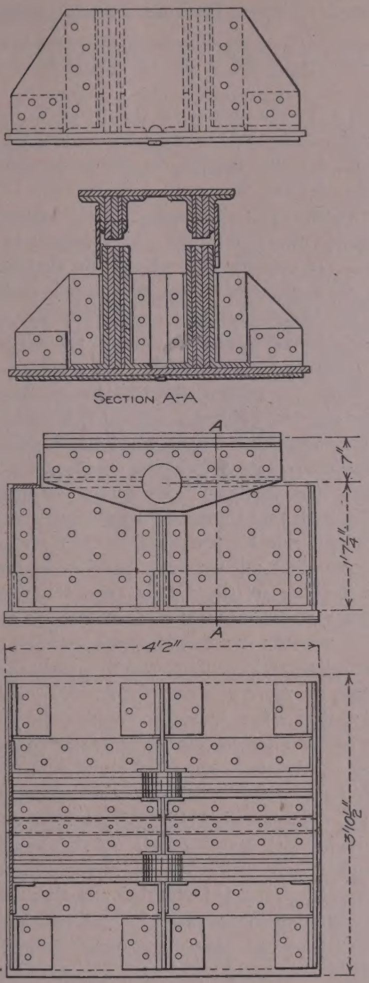
The details of the 116½-ft. girders are simple, and except in the flange construction they are generally typical of the details in the other spans. The web plates are cut to give a camber of 25-32 in. and are made in lengths of about 18½ ft. and 22 ft., spliced by four vertical rows of rivets in double cover plates reaching from inside to inside of the flange angles, and by 20 rivets in double side vertical plates over the vertical side plates in the flanges. The longer cover plates are made in two pieces, each with their joints spliced by the overlapping ends of the outside cover plates. The flange angles and flange side plates are each made in two pieces with staggered joints; those in the side plates are spliced by a pair of cover plates and 32 rivets, and those in the inside flange angles are spliced by single cover angles and horizontal flange cover plates, each containing 16 rivets. The splices for the outside flange angles are the same, except that the plates are omitted.

The vertical web stiffener angles divide the girder into panels of a uniform length of 6 ft. 1¾ in., except the 5-ft. 7-in. center panel, the 3-ft. end panel and a 6-ft. 8¾-in. panel adjacent to it. The web stiffener angles are cut to clear the horizontal legs of the inner flange angles, to which they are secured by short horizontal 6x6-in. angles. They are contained by separate short pieces across the vertical legs of the inner and outer flange angles. In the 3-ft. end panels the web is reinforced to a total thickness of 3¾ in. by two pairs of cover plates 36 in. wide and also has four pairs of 6x6x¾-in. vertical angles which extend the full depth of the girder and take bearing on the flanges of the outside angles, the inside flange angles being cut to clear them.

At the shore ends of the girders a 24x1-in. plate 3 ft. long is riveted to the bottom flange, beyond which it projects 2 in. on each side with open holes to receive bolts through the top of the shoe. At the opposite end the girder has no shoe, but the lower flange has a direct bearing about 9 ft. long on the top of the steel tower, to which it is field-riveted. At this point the top flange and web overhang the lower flange about 8½ in. so as to afford continuous supports for the floor across the interval between the ends of the girders. Plates notched to clear the vertical web stiffener angles are riveted to the horizontal legs of the inner top and bottom flange angles to receive the 4x4-in. zig-zag lateral angles and the inner flanges of the I-shape transverse struts, made of pairs of angles riveted together back to back and latticed, which have a depth equal to the distance between the angles in the flanges and are riveted to both inside and outside flange angles.

The double web shoes have 6x4-in. angles and pairs of 1-in. web plates, having half-hole pin bearings with full-hole side plates riveted on to lock with the 6-in. pins. The pedestals, about 20 in. high, correspond with the shoes except that the half-hole bearings do not have full-hole interlocking side plates and their ends are closed by transverse vertical plates to exclude dirt and moisture. Their webs are also connected by a center vertical transverse diaphragm and braced by corresponding outside gusset plates. The base is slotted to receive a center longitudinal guide rib engaging the set of ten 4-in. rollers, 3 ft. 8½ in. long, which are seated on a riveted bed plate 1½ in. thick.

The steel tower on the river pier consists of twelve longitudinal bents one in the plane of each line of girders. Each bent was shipped in two pieces connected by vertical latticing riveted in the field, and the bents are connected transversely by horizontal struts and diagonals, field riveted to make a continuous structure from end to end of the pier as indicated in the part transverse section of the bridge. Each half bent has under the ends of the girder a vertical column with an I-shaped cross-section having four 6x6x⅝-in. flange angles and two 15x⅝-in. web plates, parallel to the axis of the bridge. The column webs are extended longitudinally by a pair of 7/16-in. plates about 8 ft. long at the top stiffened at their outer edges by single 6x6x½-in. curved angles which converge to the foot of the column. These plates are made in two sections with splices and diagonal outside stiffening angles. The plates serve as long knee braces with horizontal upper flange angles affording bearing for and connection with the lower flanges of the girders. The feet of both columns in the same bent are seated on a single cast-iron pedestal 18 in. high with top and bottom plates connected by two longitudinal and five transverse vertical webs.

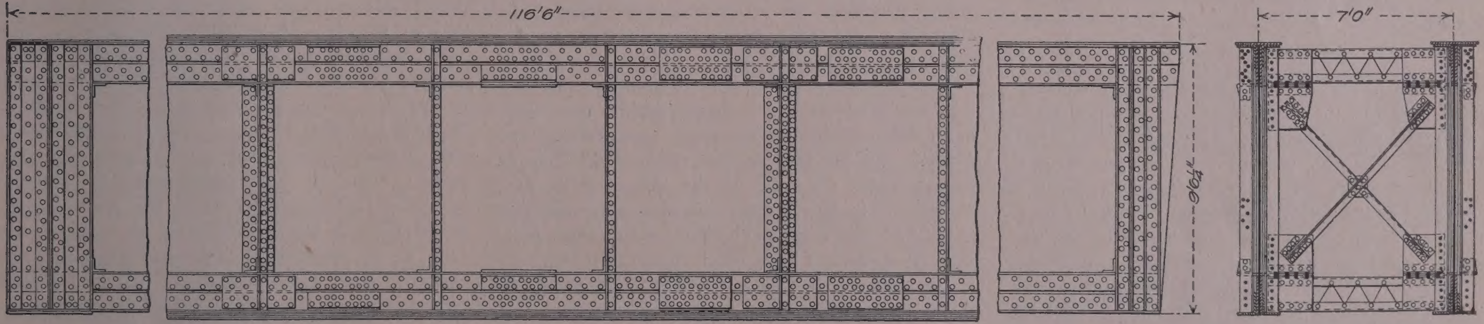


Expansion End Bearing.

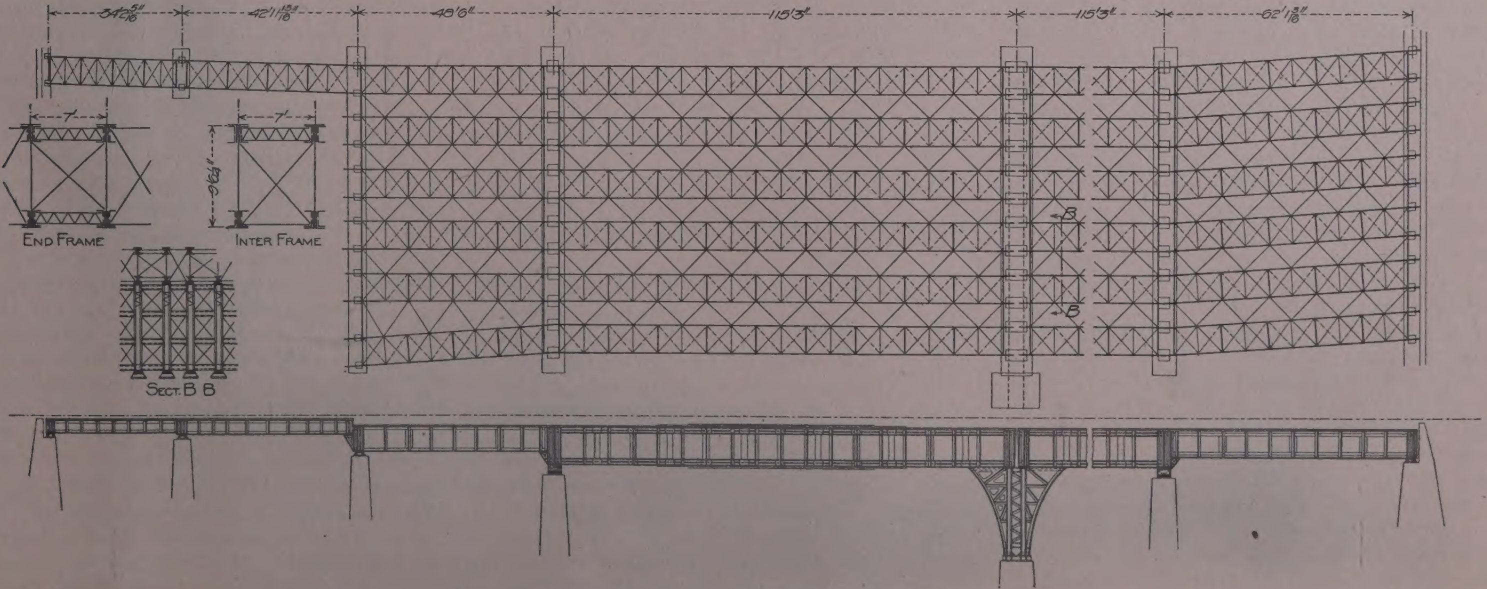
The girders in the short spans have vertical I-shaped cross sections with each flange composed of a pair of 6x6-in. full length angles with 16-in. cover plates. They are supported as indicated in the general elevation by brackets riveted to the ends of the main channel girders. At one end of the channel pier the steel tower is extended byond the outside line of girders to form a bracket support for a small steel house for the operator.

The tops of all girders in the four main spans are flush and are covered with a monolithic slab of Portland cement concrete 12 in. thick, reinforced with transverse square rods. The outer edges of the slabs project 4 ft. beyond the centers of the outside girders and are carried up vertically 27 in. to form a fascia girder retaining the ballast and supporting the hand rail. A waterproofing layer is to be placed on the concrete slab and above the top of the slab there will be 12 in. of broken stone ballast in which the ties are to be bedded with their upper surfaces flush with the top of the fascia girders.

The heaviest girders are shipped complete from the shop on three cars each and weigh about 74 tons each. At the site they are unloaded and placed in position by two of the railroad company's standard steam wrecking cars. Afterwards the transverse and lateral bracing is as-



Long Span Girder and Sway Bracing.



Sway Bracing and Plan and Elevation of Girders.

sembled and riveted, and a track laid on the new span to enable the wrecking cars to erect the next adjacent span to it and so on until all of the steel work is erected, after which the concrete floor slab is made in one continuous monolithic slab across the entire upper surface of the bridge. During erection traffic is maintained, the new structure supported and the old structure removed without the use of falsework. The new structure contains about 6,000 cu. yd. of Portland cement concrete, and about 2,600 tons of steel.

The arch leg construction was adopted for two reasons: First, because it makes a more graceful looking structure than the high pier type, and secondly, because a concrete masonry pier would have been badly cut up in order to allow it to be put in place before the removal of the old bridge, since the latter was a deck truss span of considerably greater depth than the new girders. By the plan adopted the low masonry pier for the new bridge was built while the old one was in use.

Underneath the pier supporting the west end of the long span a vein of coal about 4 ft. thick had been removed, the depth of the vein being 40 ft. below the surface. Test holes were put down to investigate the foundations, and as a result several 8-in. holes were drilled on the site of the pier into the space from which the coal had been mined. These holes were piped and very wet concrete poured through them, filling up the space and forming a good foundation for the pier.

The bridge was designed by the engineering department of the Delaware, Lackawanna & Western R. R., Mr. L. Bush, chief engineer, and Mr. A. E. Deal, bridge engineer. The contract for the fabrication of the steel work was awarded to the McClintic-Marshall Construction Co., and was built at their Pottstown plant. The masonry substructure was built and the steel work is being erected by the railroad company's forces.

A New Type of Permanent Way was suggested by Mr. J. W. Schaub at a recent meeting of the Western Society of Engineers. He developed it from the present form of tracks, with sawed cross-ties laid on rock ballast at least 16 in. deep, in the following manner: A steel I-beam is placed temporarily under each end of the ties, so that each tie has a full bearing on the beam at each end. These I-beams are tied together by rods 2 ft. apart, so as to hold the ballast between them. A stringer is laid on top of the ties at each side and held in place by a hook bolt passing through each tie and anchored to the inside flange of the I-beam. An angle iron placed on the inside edge of this stringer serves as a guard rail. After this work is done, it is proposed to remove all ballast outside of the beams. To bring such a track to surface the entire structure will be lifted by track jacks placed under the flanges of the beam. The ballast is confined between the beams, so that an arch action can take place, with the thrust of the arch taken up by the tie rods. The longitudinal beam has two distinct functions. First, the beam, which is one of the special Bethlehem sections, has a moment of inertia equal to five times that of an 80-lb. rail and should do just five times the work done by the rail when both are working together under the same conditions, neglecting the work done between the cross ties in either case. The rail would then be mainly required to distribute the load over the ties and not to make up for any deficiency in the substructure, as it does now. In the second place, in confining the ballast and thereby preventing the track structure from working its way down through the ballast, this type of construction is considered to have a decided advantage.

Recent Steam Turbine Developments.

Abridgement of a paper presented to the National Electric Light Association by Mr. W. L. R. Emmet.

From a consideration of the general principle and from some of the literature that has been produced on the subject, it might be supposed that the design of steam turbines was a very simple matter and that many good designs simply awaited the capital for their commercial production. In reality the design of turbines involves very great practical difficulties, and is in its nature dependent upon very difficult experimenting. Steam is an elastic fluid, carrying much energy, which is convertible into heat, pressure or velocity. In passing through the small spaces of a turbine at lightning speed, it is subject to eddyings, vibrations, condensations, rarefactions and re-evaporations which may have a radical effect upon the efficiency. The value of fuel and power is such that in our day inefficiency in prime movers can not be tolerated, and if we are to build engines at all, we must build good ones.

In a turbine of the Curtis type the necessity for elaborate experimental development is particularly urgent; its fundamental process being the complex action of a single steam impulse upon two or more moving blades, while in other turbines that have been produced each row of blades has a relatively independent action.

These conditions were clearly understood when production of these machines was begun, and it was not expected that the type would at once attain its highest development. At that time other forms of steam turbine were imperfectly developed, and there was demand for such undertakings as were fully justified by our early experiments. All of our early experimenting was done with small apparatus made for the purpose, and all the Curtis turbines installed prior to the last six or eight months were designed from data obtained from this experimental apparatus. These machines are of several successive types and have generally shown improvement in the order of their production.

The designs of the improved machines now being produced have not been simply dependent upon data obtained from small experimental apparatus, but are largely the result of analysis of performances of some of the earlier large machines. It is only within recent months that the results of this actual experience with large commercial apparatus have taken material form.

The main objects sought in the development of the Curtis turbines have been: High steam economy; the use of a small number of rugged parts instead of a very large number of fragile ones; the elimination of all small clearances; the economic recovery of the large energy available in high vacuum, and the production of flat load curves, particularly with reference to high overload economy. The purpose of this paper is to show the progress that has been made in pursuit of these aims. The test results given in this paper do not all apply to machines of our latest types, but they show good progress in the desired directions, and a satisfactory degree of consistency of results.

In studying the tests here given, it will be noticed that the steam consumption of smaller machines is relatively large. This is a necessary condition in all steam turbines, unless the speed can be increased in almost inverse ratio to the capacity. The natural limitations of alternating-current frequency and the desire for mechanical reliability have led us to adopt very moderate speeds for smaller machines, and thus to sacrifice degrees of steam economy which might easily be attained if we used, for the same sizes, speeds as high as those adopted by makers of turbines of other types. In spite of this disadvantage, our results in smaller sizes are relatively good and serve to demonstrate the flexibility and excellence of the Curtis idea.

During the past year four 9,000-kw. units have been installed in the Fisk St. station of the Commonwealth Electric Co., of Chicago. One of these machines has been tested at different loads by engineers employed for the purpose by the owners. These tests were part of a general investigation of station conditions, which has not yet been published. They were conducted with great care and were repeatedly verified before being accepted. Their accuracy is also proved by the results of 5,000-kw. tests as explained below. The following figures give the results of five tests that were made:

TEST OF 9,000-KW. TURBINE GENERATING UNIT AT CHICAGO.

Load in Kilowatts.	Gauge Pressure, Lbs.	Vacuum, Inches.	Superheat, Degrees F.	Water Rate, Lbs. per Kw.-Hr.
5,374	182	29.43	133	13.15
8,070	197	29.55	116	13.0
10,186	176	29.47	147	12.9
12,108	182	29.34	148	13.05
13,900	198	29.31	140	13.6

The steam economy shown by these tests we believe to be higher than any previous result within the same ranges of temperature and pressure. This machine at full load with a 28-in. vacuum delivers to the switchboard 21 per cent. of the total energy in the steam and 67.3 per cent. of the total available energy in the steam. It delivers to the shaft 70 per cent. of the total available energy in the steam.

It is interesting to consider what relation this result may bear to the ultimate possibilities of turbine improvement, and we have some information from which conceptions on this subject can be formed. The simplest application of the turbine idea is found in the delivery of steam through a straight nozzle against a single row of moving blades having a velocity best suited to the speed of issuing steam. Such simple arrangements have been tested, and efficiency curves have been traced with friction losses completely eliminated, and with all degrees of velocity in steam and in wheels. Many such investigations have been made in Schenectady, and similar investigations on an elaborate scale have been made in Germany. The best bucket efficiency produced in such test has been 75 per cent. of the available energy corresponding to the temperature range. Thus in this large commercial machine we get a shaft efficiency of 70 per cent, as compared with a bucket efficiency of only 75 per cent. in the most ideal turbine arrangement that we have been able to devise. This comparison leads us to expect that we may be nearing the limits of possible improvement in the simple production of power from steam.

An examination of these results will show that they in all respects realize the ideals that have been aimed at in the development of this kind of apparatus. The vacuum produced is almost unprecedented, and the turbine uses efficiently the large increase of available energy which this high vacuum affords. The machine gives a very flat load curve with particularly high relative economy at heavy overload. This feature, as has been explained, is characteristic of the type, and is worthy of special consideration.

High economy at overload is the direct equivalent of increased peak-load capacity, since it makes it possible to obtain a larger maximum output from a given installation of boilers, plant and auxiliaries, and from a given operating force. If units in one station have a peak-load efficiency 25 per cent. higher than those in another similar station, it implies that the peak capacity of one is 25 per cent. greater than that of the other.

When the matter is considered in this way it will be seen that these 9,000-kw. machines have very great superiority of value as compared with any other large prime movers now in use. The plant in which these units are installed was originally designed for 5,000-kw. machines, and for each generating unit a battery of eight 520-hp. boilers was installed; these batteries of boilers being the equivalent of those which had been adopted in large engine stations built at about the same time. In the test results given it will be seen that the machine tested was operated at 13,900 kw., taking its steam from these eight boilers. That the firing of these boilers during this run was not abnormally heavy is shown by the fact that the superheat carried amounted to only 140°, while the superheat was higher in other tests, and is known to be higher when boilers are forced. The superintendent of the plant in which these machines are installed has stated to the writer that they could without difficulty supply steam for 15,000 kw. if the generators were capable of carrying such a load.

The plant in Chicago in which these machines are installed is the handsomest and most substantial steam plant ever built, and yet if the units were assigned ratings equivalent to those of other prime movers its cost per kilowatt would unquestionably be the lowest that has been produced. Consideration of the economies from this standpoint will show any unprejudiced investigator the wastefulness of using inferior apparatus when such results are obtainable. It will also show the great advantages of power production on a large scale, and will indicate that great changes in existing methods are to be looked for at an early date.

Another feature of these tests which will immediately impress every one who is familiar with steam practice is the extremely high degrees of vacuum that are carried. The machine tested is equipped with a base condenser which forms an integral part of the turbine unit. This condenser contains 25,000 sq. ft. of tube surface with 1-in. tubes. The record shows that there was no appreciable diminution of vacuum with increased load. This high vacuum is due to the free access of steam to the tube surface and to the absence of any air leakage for which this arrangement provides. The value of such high vacuum is very great when the prime mover used is capable of effectively getting the benefit of it. The available energy with a 29-in. vacuum is 10 per cent. higher than that with a 28-in. vacuum, and in this machine at full load the gain of water rate accomplished by increasing the vacuum from 28 to 29 in. amounts to 7 per cent. The machine was designed for 28.5 in. of vacuum, and between 28 and 28.5 in. the gain is very nearly proportionate to theory.

The test results obtained in Chicago have been amply verified by tests that have been made in Boston and Schenectady upon 5,000-kw. machines of similar design. One of these machines was tested in the new plant of the Boston Edison Co. on January 29, 1907, and gave the following results, which when reduced to similar conditions are only about 0.3 lb. inferior to those obtained at Chicago: Load, 5,195 kw.; gauge pressure, 174 lb.; vacuum, 29.3 in.; superheat, 142° F.; water rate, 13.52 lb. per kw. hr. This difference from the Chicago figures is fully accounted for in the losses of the generator alone.

This test in Boston was verified by three separate runs with different sets of instruments; some of which were specially calibrated for the purpose.

In order to judge the results accomplished by this recent turbine development, it is interesting to make a comparison with a large reciprocating engine of the type which large turbines are superseding. The results obtained by test from one of the 5,000-kw. engines in one of the Interborough Rapid Transit Co.'s plants, published by Mr. H. G. Stott in a paper presented to the American Institute of Electrical Engineers about a year ago, may be plotted on the same diagram with the turbine results, when the curves will show a difference of steam economy at all loads equivalent to a very large fuel saving, and the great superiority at overload shows that such a turbine if installed in the same station would give a very much greater peak capacity. From this comparison it can easily be calculated that the cheapest way to enlarge a reciprocating engine station is to install turbines in place of the engines.

In addition to these advantages in the matter of capacity and fuel consumption, the turbine has many practical merits which need not be enumerated. There is, however, one point, brought up by recent experience, which is interesting in this connection. The large turbines here described operate with very large clearances, and consequently are in no way subject to deterioration by wear or increase of leakage. The economy of reciprocating engines is greatly affected by leakage and by correct adjustment. We recently made a test of three reciprocating engines operating a large plant, each having a rating of about 2,000 h.-p. It was found that they all gave a steam consumption of about 34 lb. per kilowatt-hour condensing, while the same engines if in adjustment would consume not more than 20 lb. per kilowatt-hour.

The vertical-shaft steam turbine has been rapidly introduced, and machines of this type have been installed in great numbers in all parts of the world. Many different designs have been made to met different conditions, and, as is natural in such a process, mistakes have been made which in some cases have caused serious inconvenience. The most serious troubles have arisen from unexpected tendencies to vibration in certain particular designs. The balanced condition of a vertical machine is peculiar, and certain conditions must be conformed to in order that steady running may be obtained. Certain machines that have given trouble in this respect have been sent out in considerable numbers, and in many cases it has been impossible to afford immediate relief for the trouble. Generally speaking, however, the vertical type has shown itself to be wonderfully dependable and free from many of the difficulties which endanger the operation of other kinds of machinery.

Our more recent experiences have enabled us to greatly improve all the mechanical conditions governing the action of our turbines. Bearings and steam packings are much improved. The valve mechanisms have been brought to a simple and reliable condition. Means for providing freedom from vibration have been discovered, and all parts have been designed and proportioned in the light of experience.

In connection with steam units that are capable of affording such high degrees of overload economy, it is particularly desirable that generators be used that are capable of operating continuously with very heavy overloads, and efforts are being made to accomplish this result, both in connection with machines already installed, and with new designs that are being produced. On account of the necessary compactness of high-speed electrical apparatus, the losses are concentrated into a very small space, and the dissipation of heat produced presents an interesting problem. If air is used for cooling electrical apparatus, about 90 cu. ft. rising 20° C. in temperature will carry away the heat equivalent of about one kilowatt. From this is appears that to dissipate the heat from one of the large units above described when operating at 15,000 kw., it will be necessary to circulate 35,000 cu. ft. of air a minute, notwithstanding the fact that the efficiency of the generator under that condition is considerably over 97 per cent. Where such units are installed in stations and allowed to take their ventilating air from the room, they are liable to get an insufficient supply, or to draw in air which has already been heated by contact with other heated surfaces. It is therefore desirable to make arrangements in such station by which an ample supply of air for ventilating generators is obtained from outside of the building. In many existing plants it would be economical and desirable to install blowing apparatus, in order to provide for increased capacity, and in other cases where apparatus is designed to move large quantities of air, it would be desirable to make connection to sources of cool air, without the necessity of blowers. In every case coolness of the apparatus should be sought as a measure of safety and reserve capacity.

Tall Building Foundations on Soft Clay.

When the designs were made for the 15-story steel cage building of the Traders' Bank of Canada, Toronto, Canada, the designers in New York were advised that the site was on a deep stratum of hard clay of great strength with an almost unlimited bearing capacity. They therefore designed separate rectangular concrete piers calculated to reduce the maximum column loads to a pressure of about 10,000 lb. per sq. ft.

The site of the building has apparently at one time been a part of the lake bottom and consists of a deep sedimentary stratum of clay, the upper portion of which has been solidified into a very hard dry crust, which, as was stated, proved very reliable and satisfactory for the ordinary buildings of 4 to 6 stories in height adjacent to the bank building. The footings of these buildings were, however, carried down only about 12 ft. below the curb, while those of the new ones extend to a depth of about 25 ft.

When the excavation was made it was noted that the clay softened slightly below the surface, until at a depth of 17 ft. there was a rapid change noticeable, and the consistency became very soft, like putty. It was, however, moderately dry and tenacious, but evidently could not be depended to carry a heavy load after penetrating the upper crust, although if that were undisturbed for a reasonable thickness above the soft stratum, it was, something like that of the analagous stratum in Chicago, competent to carry ordinary loads satisfactorily.

In order to secure an accurate test of its bearing capacity, Mr. Brainard had a pit excavated to a depth of 20 ft. below the curb and in the center of the bottom prepared a bearing surface with great care, taking pains to personally dress and scrape it to an exactly uniform horizontal surface with a 14-in. steel straight edge. The ends of a 12x12-in. timber about 6 ft. long were then cut exactly square and smooth and a horizontal platform about 4 ft. square was secured at the upper end. Two pairs of horizontal guide strips at right angles to each other were set across the pit to closely engage the four faces of the 12x12-in. post and it was carefully plumbed and lowered through them until its foot rested exactly on the point previously determined by a plumb bob on the prepared surface in the center of the pit.

It was thus seated accurately with an even bearing and uniform contact over the entire surface. A leveling instrument was sighted on the vertical gauge rod projecting above the platform and the latter was quickly loaded with 2 tons of pig iron. No movement was detected until 2½ tons were placed on the platform, when it settled rapidly for three-eighths of an inch and the loading ceased. During the night the settlement continued and had reached at least 1½ in. on the following morning. There was some upheaval of the clay around the foot of the 12x12-in. column and although the results were considered to entirely eliminate the misleading initial settlement often due to carelessly applying the test load on an imperfect bearing, they were not considered as conclusive of the actual capacity of the soil because the isolated area tested was not under the same conditions as a unit of equal size in the midst of a large footing.

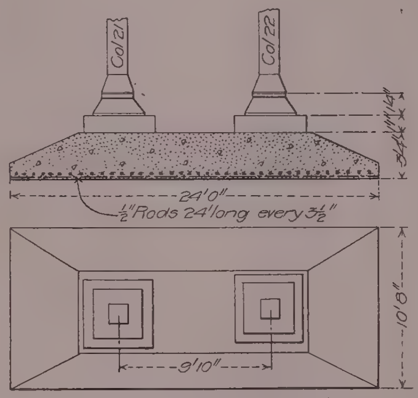
This test was, therefore, supplemented by a second one made under conditions intended to approximate more closely to those realized in the finished structure. A 6-in. pipe with the lower edge beveled on the outside at an angle of 45 deg., to a sharp edge, was driven about 8 in. into the bottom of the pit 20 ft. below the curb and caused, as was expected, a slight upheaval around the outer side. Inside the clay remained apparently undisturbed with the upper surface at the original level. It was assumed that the inside clay thus isolated and confined would correspond closely with that under the center of a large footing where the lateral forces might be considered to be balanced.

In the pipe there was inserted an oak piston which had a carefully squared lower end and was fitted to the interior of the pipe for a length of 2 in. above which the diameter was diminished sufficiently to insure absolute clearance. The piston projected above the top of the pipe and carried on its upper end a horizontal platform, properly guided between horizontal struts, loaded with pig iron, giving a pressure of 4 tons per sq. ft. on the lower end of the piston. No settlement whatever was detected from this load; it was increased to 5 tons without causing any settlement, and it was decided to be safe to load the footings uniformly to 4 tons per sq. ft., and the foundations were accordingly designed on this basis. They have been subjected to their full load since August, and no settlement has been perceptible by the most careful instrumental observations.

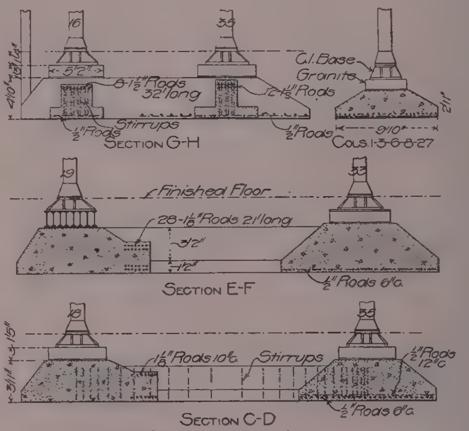
The foundations designed in accordance with these tests cover about one-half of the total area of a 105x95-ft. rectangle and consist of separate and connected concrete piers and continuous concrete footings uniting adjacent piers and serving both to extend the bearing surface and as distributing girders providing for the eccentric location of the columns. In one corner of the building where the center line of the wall is outside that of the footing, the condition is one usually met by seating cantilever girders on the grillages with the wall columns supported on their overhang and the opposite ends anchored by interior columns. As this construction would have involved considerable delay for the delivery of the steel girders, a method was devised of securing the same effect with reinforced concrete which could be made at a smaller cost and without delay.

The piers for the wall columns and for adjacent interior columns were made integral with footings symmetrical about the center line of the columns and the latter were provided with center vertical webs and reinforced full length horizontal steel rods in the upper flange and with vertical stirrups proportioned to the shearing force, thus making a T-shaped beam or girder with a uniformly distributed load on the lower side and two concentrated loads on the upper side. The lower faces of the pedestals and footings were reinforced with single and double tiers of horizontal rods and the outer edges were beveled at about 45 deg. from a height of about 12 in. above the base to the top, 4 ft. high. Rods ½ in. in diameter and 6 in. apart were used in the pedestals, and 1½-in. rods were used in the girders. The concrete was made 1:2½:5 with Portland cement and broken stone, the latter being 2 in. diam. for walls, and ½ in. for reinforced work. It was proportioned for a working stress of 300 lb. per sq. in. in compression, the rods being calculated to carry all the tension with a stress of 18,000 lb. per sq. in. The column loads were transmitted through cast-iron pedestals to grillages consisting of single tiers of 15-in. I-beams which distributed them on the upper surface of the concrete pier with a maximum pressure of 30,000 lb. per sq. ft. The grillages and pedestals were enclosed in concrete of a minimum thickness of 4 in. and the pits around them were back filled and covered with the 6-in. concrete floor at the level of the column basis.

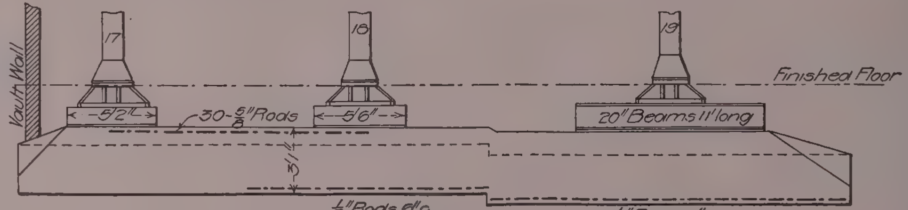
Carere & Hastings, of New York, and Mr. S. S. Baker, Toronto, are the associated architects, and Mr. Owen Brainard, consulting structural engineer. The V. J. Hedden & Sons Co., New York, was the general contractor.



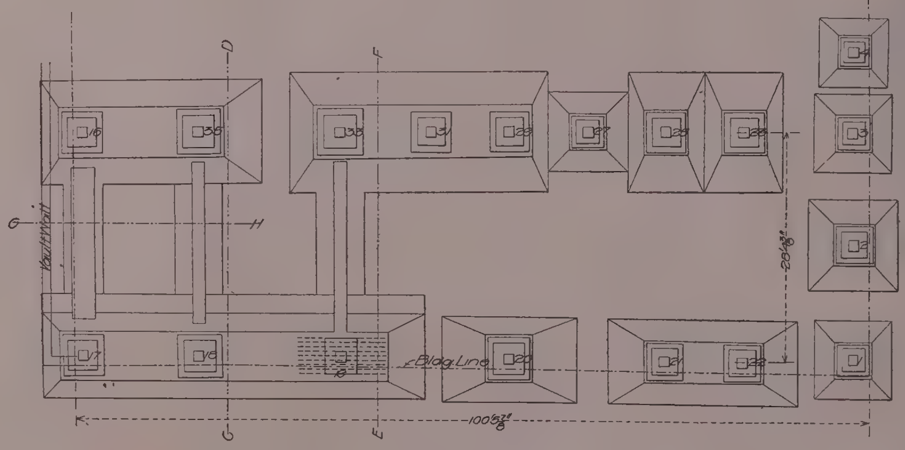
Plan and Section of Footing.



Sections of Footings.



Elevation of Columns and Footings.

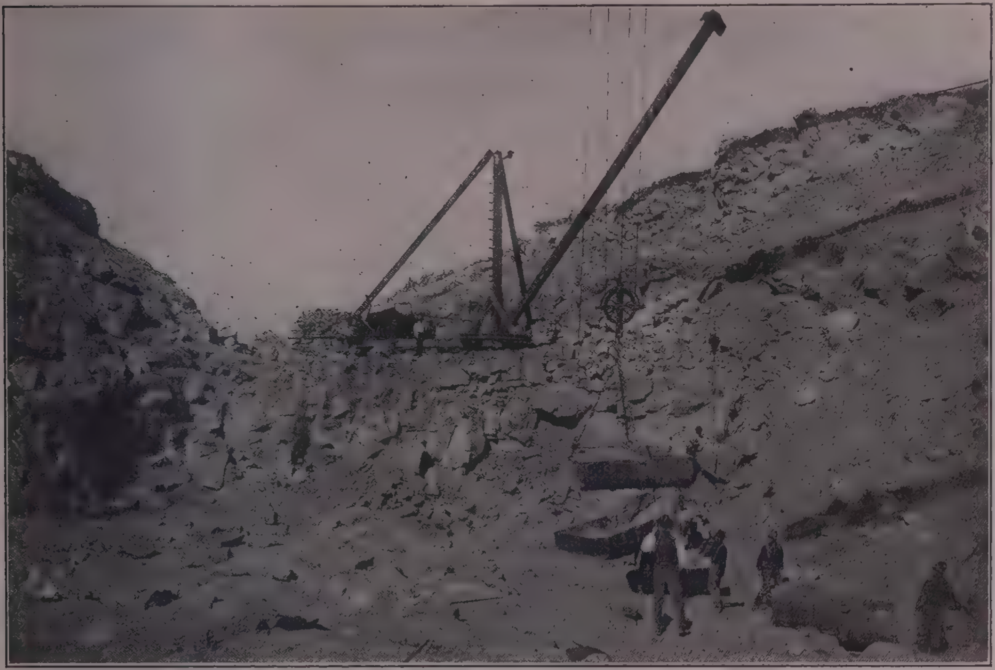


Foundation Plan, Traders' Bank of Canada.

The tests above described for the bearing capacity of the soil are in line with another interesting test recently made by Mr. Brainard for a building in the United States where somewhat different details were adopted to insure absolute conformity to the conditions which were anticipated in the finished structure. The building is located on the top of a high slope of coarse dry sand. Excavation was made to the cellar floor level and a test pit was sunk 6 ft. farther with flat sloping sides to the required level of the bottom of the foundations. The surface of this bottom was level and in the center a horizontal bearing about 15 in. square was prepared with great accuracy, as described for the Toronto Building. This was then enclosed by a rectangular wooden frame or curve 12¼ in. square inside and the upper surface, outside of the curb was covered with 6-in. of very rich quick-setting concrete. A 12x12-in. vertical timber 6 ft. long with an accurately squared lower end was then set with great care on the surface of the sand inside the curb and the upper end, carrying a loaded platform, was secured between horizontal guide timbers reaching across the pit in both directions as previously described. The vertical timber was then enclosed below the guides with sheeting forming a rectangular sleeve just clearing it and excluding the back fill which was moistened and packed solid around it filling the pit on top of the concrete to a height of 6 ft. The sand under the concrete was thus protected and moderately loaded to correspond with that between the foundation piers of the building after the excavation had been back filled and the cellar floor laid. Five tons of pig iron was placed on the loading platform without causing any settlement that could be detected by the most careful instrumental observation. In accordance with this test the foundations have been proportioned for a uniform load of 8,000 lb. per sq. ft., and no allowance is made in the superstructure for settlement. In all of the tests here described the care exercised to secure accurate contact with the soil and uniform bearing on it has entirely prevented any displacement of the platform until the load on it equals the bearing capacity of the soil, and by thus eliminating the so-called initial settlement has greatly strengthened the experimenter's confidence in his results.

The Contractor's Plant and Methods Used on the Minidoka Irrigation Project.

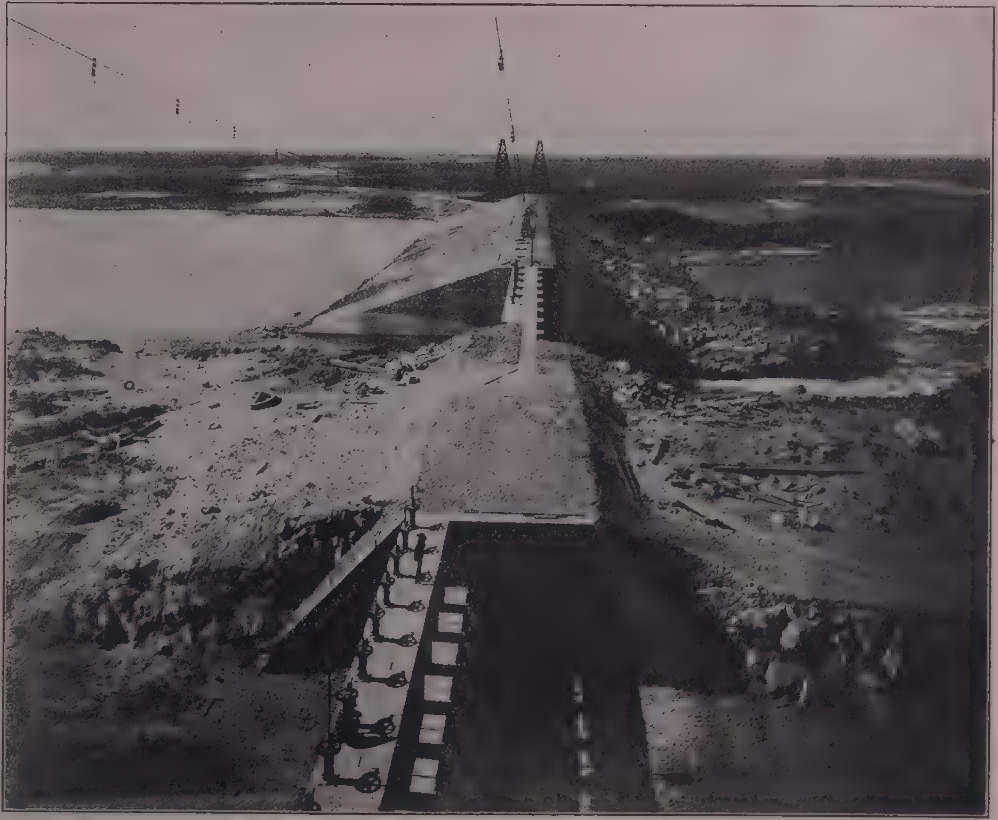
The Minidoka irrigation project of the U. S. Reclamation Service, in the south central part of Idaho, embraces among other things a dam across the Snake River, a controlling works and the headworks for a main irrigation canal at one end of this dam and a long spillway and the headworks for a second main canal at the other end of the dam. The general engineering features of this project were quite fully described in The Engineering Record for March 2, 1907. The dam is about 8 miles southwest of the town of Minidoka, which is on the Oregon Short Line R. R. All camp and construction supplies and such construction materials that were not available at the site of the dam were hauled to the latter in wagons over a road built by the contractors from Minidoka. The first four miles of this highway is through level sandy country and the remainder is through rough rolling land of volcanic origin that is largely lava rock. Although this road was heavy in many places, teaming over it did not involve any particularly unusual difficulties, but the great amount of hauling which had to be done required a large number of horses and wagons.



Stiff-Leg Derrick Used in Diversion Channel Excavation.

At the site of the dam the river is comparatively narrow and formerly contained a series of small rapids. The valley of the river narrows to a width of 500 to 600 ft. at the site of the dam, widening out rapidly above and below the latter. The dam proper is built of loose rock, earth and gravel, with a concrete masonry core wall and contains 191,000 cu. yd. of material. It is 625 ft. long, has a width of 25 ft. at the top and an average width of 300 ft. at the bottom and rises 60 ft. above the bed of the river, which is solid lava rock. The controlling works are across a diversion channel that was excavated at the end of the dam and are built of concrete. These works were designed with the expectation that a power house will be erected over them; they contain 10-ft. circular openings for water-wheel penstocks and five 8x12-ft. sluiceway openings fitted with Coffin sluice gates. The diversion channel is 80 ft. wide at these works and is 100 ft. from the edge of the original river bank at that point, connecting above and below the dam with the river. The controlling works are all built on bedrock. They are connected at one end with the core wall of the dam and at the other end by a wall 70 ft. long, with the headworks of the irrigation canal on that side. These headworks are built of reinforced concrete and contain nine 5x7-ft. openings controlled by sluice gates.

The spillway which extends from the end of the dam opposite the controlling works is built of concrete and has a total length of one-half mile, following a sinuous course across the valley to the headworks of the irrigation canal on that side. These works are built of reinforced concrete and contain twelve 5x6-ft. gate openings, each controlled by a Coffin sluice gate. An earth embankment, 800 ft. long, extends from these headworks to higher ground on this side of the river.



Headworks of One Canal, Controlling Works and Main Dam.

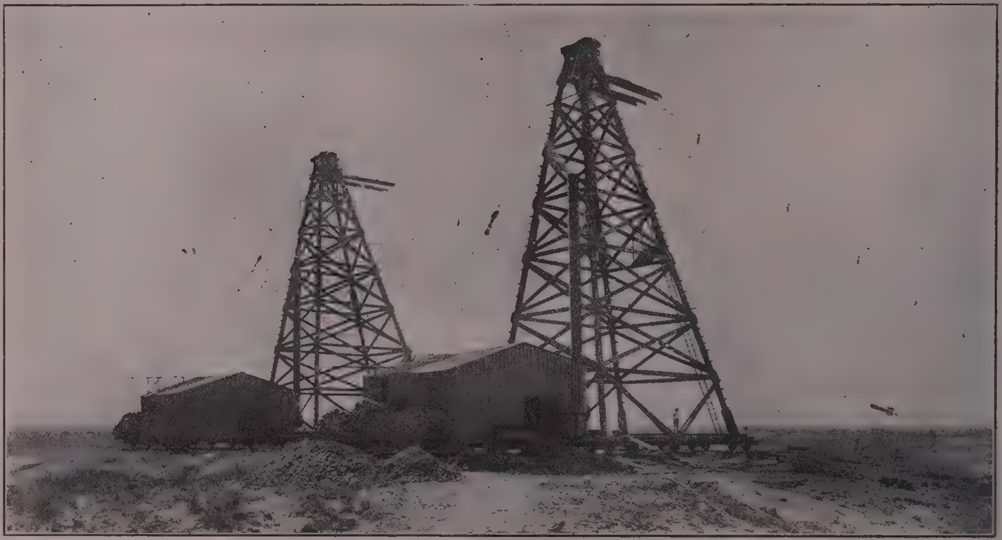
The excavation of the diversion channel and the construction of the controlling works were started first, the material taken out of the channel being used to build the dam. Two 1,150-ft. span Flory cableways, having a capacity of 5 tons each, were set up parallel with the axis of the dam spanning the latter and the controlling works. These cableways had an 80-ft. traveling tower at each end, the head tower being on the controlling works side of the river, and could be moved about 150 ft. at right angles to the axis of the dam. Each cableway was equipped with a 2-in. patent lock main cable and was operated by a three-drum hoisting engine built by the Flory Mfg. Co.

The excavation of the diversion channel was largely all in lava rock, Ingersoll-Sargeant air drills being used to make the blast holes. Air under pressure for operating these drills was furnished by an Ingersoll-Sergeant compressor, with a capacity of 800 cu. ft. of free air per minute, which was installed in a power plant building about 800 ft. from the controlling works. This compressor also furnished air for operating the concrete mixer, the hoisting engines for derricks used in connection with the cableways and a pump at the river which supplied a system of water-works extending to all parts of the work and to the construction camp. An alternating-current generator was also installed in this power plant building and furnished power for lighting the works and the camp. As construction work was in progress night and day during a greater part of the time, this lighting outfit proved to be of much value. The coal for the power plant was obtained from mines at Kemmerer, Wyo., and was delivered in cars to Minidoka, and was then hauled in wagons to the work. Over 4,000 tons of coal were consumed during the two years the construction was under way, so the outlay of money and time involved in the coal supply were very considerable.

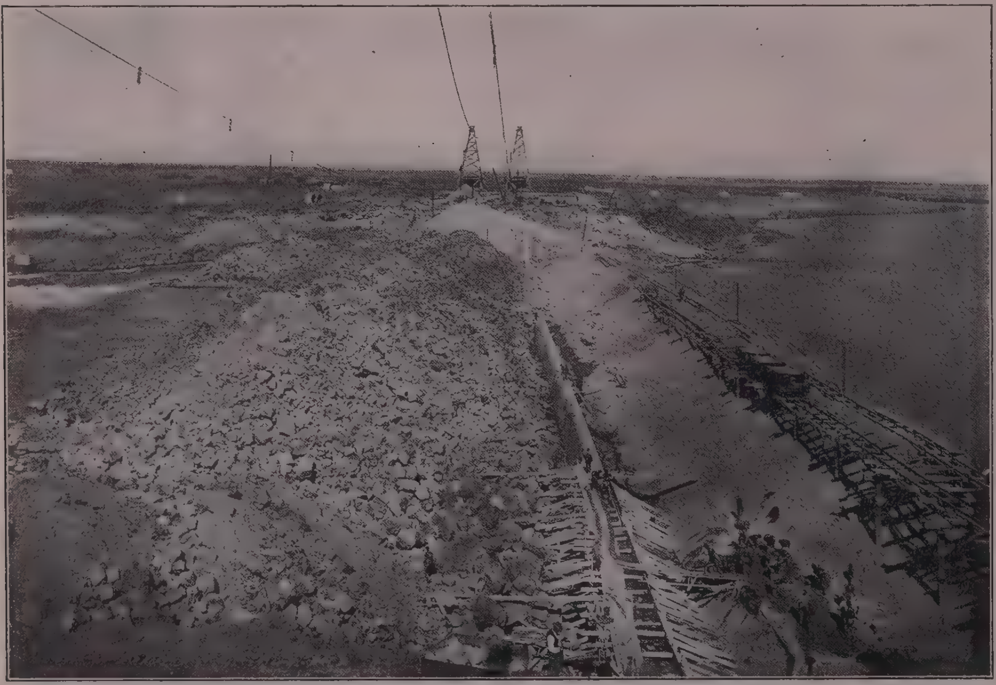
The diversion channel excavation required the removal of about 77,000 cu. yd. of material. The first 5 to 20 ft. of this excavation was made through a stratum of practically solid lava rock under which was a 12 to 15-ft. stratum of sand and loose rock, which overlies the bedrock, the latter being also a lava formation. Within the reach of the cableways the rock was loaded into 3-yd. skips at the face of the excavation by means of the cableways and was carried out and dumped into the portion of the dam downstream from the core wall. The parts of the excavation close to the path of the cableways, but out of the reach of the latter, were served by stiff-leg derricks set on the sides of the excavation, the skips being handled from the face of the latter to the cableways by these derricks. A 36-in. gauge track was extended to each end of the diversion channel from the path of the cableways and served the portion of the face of the excavation that could not be reached by the cableways.

The stratum of sand under the upper stratum of rock caused considerable trouble in making the diversion channel excavation. After a portion of the channel had been cut to the required cross section this loose material would run out and leave the upper rock unsupported; this upper rock would then break off and fall into the excavation. The result was that a slope of at least 2½ to 1 had to be made on the face of the loose material and the upper rock above it had to be removed back to the top of this slope. The latter also had to be riprapped with heavy rubble where the water was liable to strike it, this riprap being held in place by a concrete lining wall built along the side of the channel. The presence of this unexpected stratum of loose material also necessitated quite a change to be made in the arrangement of the controlling works.

The controlling works rise to a height of 58 ft. above the bottom of diversion channel, or 70 ft. above the upstream end of the tail race of the power house, and together with the headworks of the canal on that side and the wall connecting them with those works, contain 8,200 cu. yd. of concrete and 55,000 lb. of reinforcing steel. The concrete for the controlling works was made in the proportion of 1 part cement to 7 parts gravel, and was all mixed in a Smith mixer mounted on a platform on a tower erected in the channel. The gravel was obtained from a borrow pit on the opposite bank of the river and was brought across the latter in 3-yd. dump cars operated on a double-track trestle used in the construction of the dam. One of the tracks on this trestle was extended over the concrete mixing plant so the gravel could be discharged into a storage bin, with a capacity of 100 cu. yd., erected over the mixer. The cement was stored in a shed near at hand and was delivered to the mixer platform as required. The mixer discharged into one-half-yard buckets on flat cars on a narrow-gauge track extended to the work. These buckets were handled to place in the forms by a stiff-leg derrick, with a 65-ft. boom, which was set on a tower, 30 ft. high, in the channel on the upper sides of the works.



Eighty-Foot Head Towers of 1,150-Ft. Span Cableways.



Concrete Core Wall of Main Dam under Construction.

The five 8x12-ft. cast-iron sluice gates included in the controlling works weigh 13 tons each and were brought overland on wagons from Minidoka. They were let down the sides of the excavation on runways built of heavy timbers and were then delivered to place on rollers. A number of the other sluice gates used in connection with the project were delivered and placed in the same manner. The work of placing these heavy gates was all done without a mishap.

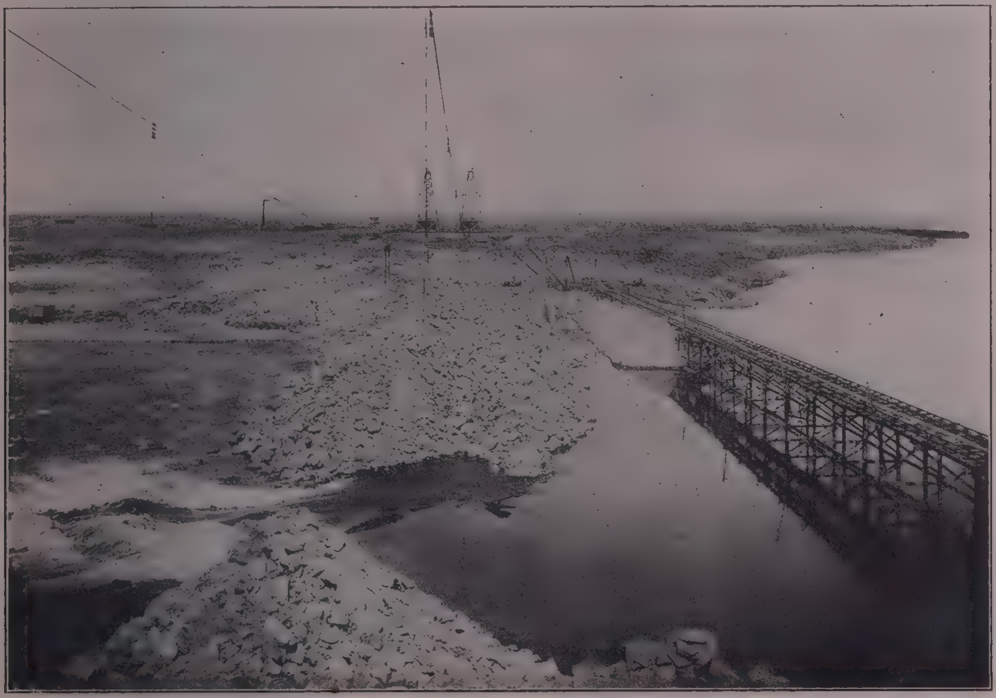
A cofferdam was built across the upstream end of the excavation for the diversion channel to prevent the latter being flooded from the river. An unusually high stage of water occurred when the diversion channel excavation was nearly completed and swept away this cofferdam. The resulting rush of water through the channel wrecked the construction plant, but operations were resumed in a few hours after the accident. Otherwise than this one mishap no others—besides those already noted—were experienced.

The headworks for the irrigation canal on the controlling works side of the river and the wall connecting these works and the controlling works were built after the dam was approaching completion. The same buried stratum of loose rock and sand encountered in building the diversion channel was found again in the excavation for the headworks and caused several changes to be made on the latter. The Smith mixer used in the construction of the controlling works was moved up near the headworks and produced the concrete used in those works.

The dam consists of large rock on the downstream side, the minimum pieces weighing 1,000 lb., and from that size up to pieces weighing 5 tons; these large stone grade off to smaller ones and finally to gravel toward the middle of the dam, the upstream side of the latter being earth and fine gravel, with the upper part of the slope paved with heavy riprap. The rock was all obtained from the excavation for the diversion channel and for the main irrigation canal and was handled to place by the cableways. Lines were wound on the three-drum hoisting engines operating the cableways so the 3-yd. skips in which the rock was handled could be dumped in the air by the operator in the head tower, the specifications requiring that this rock be dumped from a height of at least 10 ft. The gravel and earth for the dam were obtained from borrow pits on the bank of the river opposite from the controlling works. A 36-in. gauge track, with branches, was laid from the end of the dam to this pit. A traveling stiff-leg American derrick handling a 1-yd. Hayward orange-peel bucket was installed on a 30-ft. gauge track in the pit and delivered to 3-yd. Kilbourne & Jacobs dump cars on the narrow-gauge tracks. Wheel scrapers dumping through a trap into the cars were also used later to supplement the orange-peel excavator. The cars were hauled to the base of a short incline at the dam by horses and were then drawn up this incline by a hoisting engine.

A timber trestle carrying two 36-in. gauge tracks extended across the river parallel with the axis of the dam at the upstream toe of the latter. This trestle had bents, with the 10x10-in. plumb posts and a cap, spaced 14 ft. apart, each bent being thoroughly cross and sway-braced and the adjunct bents braced together. The trestle bents were erected partially on sills and the balance directly on the bottom of the river, the average low water depth of the latter varying from 3 to 25 ft. across the stream and the maximum height of water during construction was about 12 ft. above that level. The two tracks on the trestle were on a slight down grade from the hoisting engine at the end of the dam so the loaded cars would run by gravity to the point where they were to be unloaded in the dam. The cars were generally run down in trains of three, a cable on the drum of the hoisting engine being attached to each train. After the cars had been dumped they were drawn back across the river by the hoisting engine.

The rock portion of the dam was built from the controlling works side of the river, some rock being deposited on the opposite bank to prevent the erosion of the latter as the river channel became restricted. The earth and gravel part of the dam was also carried forward from the controlling works side of the river by dumping from the double-track trestle. At first the rock fill and the earth embankment were both made so the site of the core wall was not covered. After the embankment and the fill had been carried out about half-way across the river to partial height their outer ends were joined and the core wall of that part of the dam was built in the cofferdam thus formed. The concrete for this part of the core wall was also mixed on the controlling works side of the river and was handled to place in buckets by the cableways.



Closing Rock-Fill Portion of Main Dam.

Meanwhile the rock fill part of the dam was extended across the river and the diversion channel was completed. The river channel was closed by the rock fill in April, 1906, and after that the flow of the river was sent through the diversion channel. This closure was made at the beginning of the period of annual floods in the river, and for over three months after that the construction work was carried on as a night and day race to keep the dam above the high water level. The rock fill as first carried across the river was brought to about elevation 4,235 and was then raised to elevation 4,245 before high water; the finished crest of the dam is at elevation 4,250 and the crest of the long spillway at one end of the dam at elevation 4,240, high water not being expected to exceed elevation 4,244. The earth and gravel part of the dam was raised to elevation 4,225 from the trestle. It was then completed from a track laid on the upstream side of the rock fill, the material being dumped from cars on this track.

A large amount of water, estimated as 1,000 second-feet, leaked through the rock fill when the water rose above the earth and gravel embankment. The level of the water above the dam was kept at such a height by manipulating the gates in the controlling works, that the earth and gravel were sluiced into the interstices of the rock fill and entirely stopped the leakage through the latter. The river reached a flow of 24,290 second-feet on June 20, 1906, and with the five 8x12-ft. sluice gates in the controlling works running full, rose nearly to the top of five of the 10-ft. penstock openings in the controlling works. The water came within only 3.2 ft. of the crest of the weir during this high stage, however, and after that began to fall so that no further delay was occasioned from it.

The construction of the long concrete spillway which had been completed while the dam was being built involved some very difficult form work. The back face of the spillway has a batter of 1 in. to the foot from the vertical; the crest is a vertical curve with a radius of 3.24 ft.; the lower part of the front face is a curved surface, with a 6.48-ft. radius, which is connected with the curved crest by a short straight section battered 1 on 2. The spillway is built on an irregular ridge of lava rock following a very winding course from the dam to headworks of the irrigation canal on that side. It is broken at several places where the rock rises above the level of its crest, and has a maximum height of 14 ft. The curves of the cross-section of the spillway and the irregular course and height of the latter developed many warped surfaces which had to be carefully followed in the construction of the forms.

The spillway contains 4,000 cu. yd. of concrete which was made in a Ransome mixer mounted on a four-wheel truck on which it was moved forward as the work progressed. The spillway was generally built in sections about 40 ft. long, the ends of the old and new concrete being keyed together. The gravel for the concrete was obtained from the borrow pits. The contract for the dam and the works connected with it. together with sections of both main irrigation canals next to the works, was executed by the Bates & Rogers Construction Co., of Chicago, who supplied the notes from which the foregoing description was prepared.

A STEEL SLEEPING CAR has been built by the Pullman Co. and will be exhibited at the Jamestown Exposition. It conforms to the ordinary Pullman standard in design, but no wood is used in its construction. Even the seat frames, the fronts of the berths, the window sash and the ornamental side paneling are of metal.

The Vibration of Textile Mills.

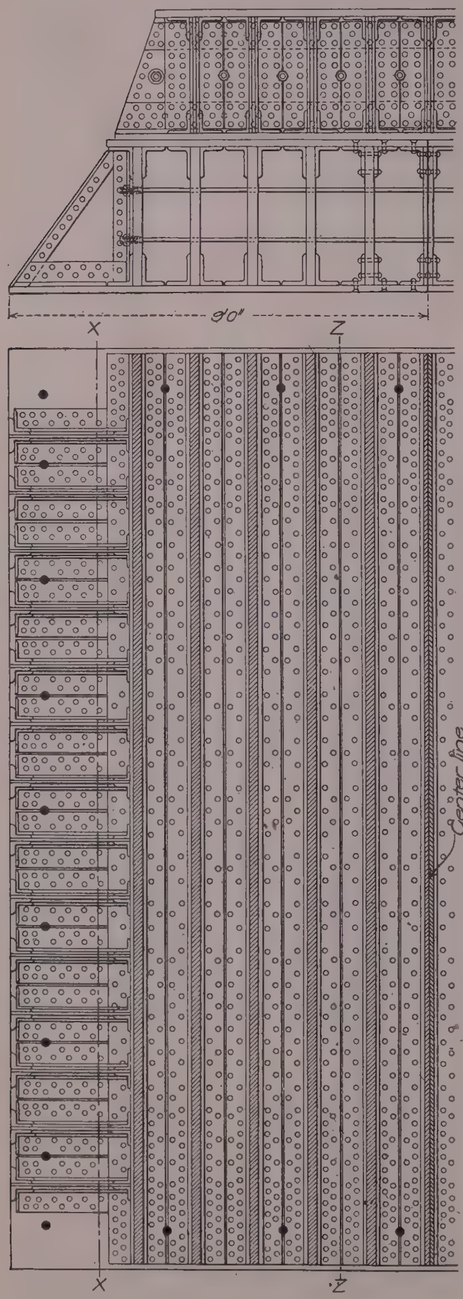
The vibration of textile mills has been investigated by means of an instrument consisting of a heavy weight suspended in neutral equilibrium from a standard and base plate. The supports for the weight have steel pin-point bearings and there are adjusting screws so that the weight may be delicately balanced. A light needle connects to the weight and the position of the fulcrum is such that the actual motion is magnified four times. A smoked glass resting on a carriage actuated by clockwork receives the movement of the needle. The permanent record is made by printing from the smoked glass. An account of some investigations made with this instrument has been contributed by Mr. E. D. Whipple to the "Journal of the Worcester Polytechnic Institute," from which the following memoranda are taken. He states that in Providence there is a building which is 8 in. out of plumb in a height of 50 ft. It is a wooden structure and, except the outside walls, is standard mill construction. The wrenching of this building was caused by webbing looms, some of which were on the fourth floor. Such looms are fairly heavy machines, and when they beat in unison heavy vibrations may occur. Another case in which the machinery caused trouble was that of a mill 250 ft. long, 60 ft. wide and three stories high, which had 36 webbing looms on the second floor. They were so arranged that the motion was in the direction of the length of the mill. The constant movement against the end walls started cracks which ran from the arch of one window to the sill of the next window in each story. The amount of vibration is very small, but it is extremely disagreeable to people having offices on the same floor, and when it is at its maximum it is quite impossible to write there. Other observations were made in a four-story stone mill, 60 ft. wide by 175 ft. long. The walls are 22 in. thick at the fourth floor and 34 in. at the first floor and rest on piles. In this case the motion was in the direction of the mill, and it resulted in the end walls starting away from the side walls. To check this the end walls were tied together by 2-in. iron rods, three of which, 10 ft. apart, were run the length of the mill and supported by the main beams of the second floor. A large cast-iron washer was placed on the end of each rod on the outside of the mill wall; the threaded ends of the rods served as a means to put tension on them. Although the vibration is heavy, the general condition of the structure remains good. Mr. Whipple suggests that to overcome the difficulties caused by weaving machinery it is without doubt the best practice to keep such machines as near the ground as possible. They may be placed on a solid floor of tar concrete, hemlock and maple in the first floor of the building. If the drive is preferred from under the floor, a low basement may be arranged, but he considers it essential that the floor be anchored so that it cannot slide and all piers for supporting the floor must be of brick or concrete of rectangular section, the longer dimension to extend in the direction of the beat of the loom.

THE NEW SWISS TUNNEL project advocated by Major Locher, the contractor for the Simplon tunnel, and backed by the Canton of the Grisons starts at Coire and connects at Chiavenna with the electric railway running to that Italian city. Its leading feature is a tunnel 26,135 meters long under the Spluegen Pass. The tunnel grades upward from the north portal at 0.3 per cent for a distance of 13,585 meters from the portal and then falls on a grade of 1.85 per cent. to the south portal. It is proposed to construct a single-track tunnel with three passing sidings about 500 meters long.

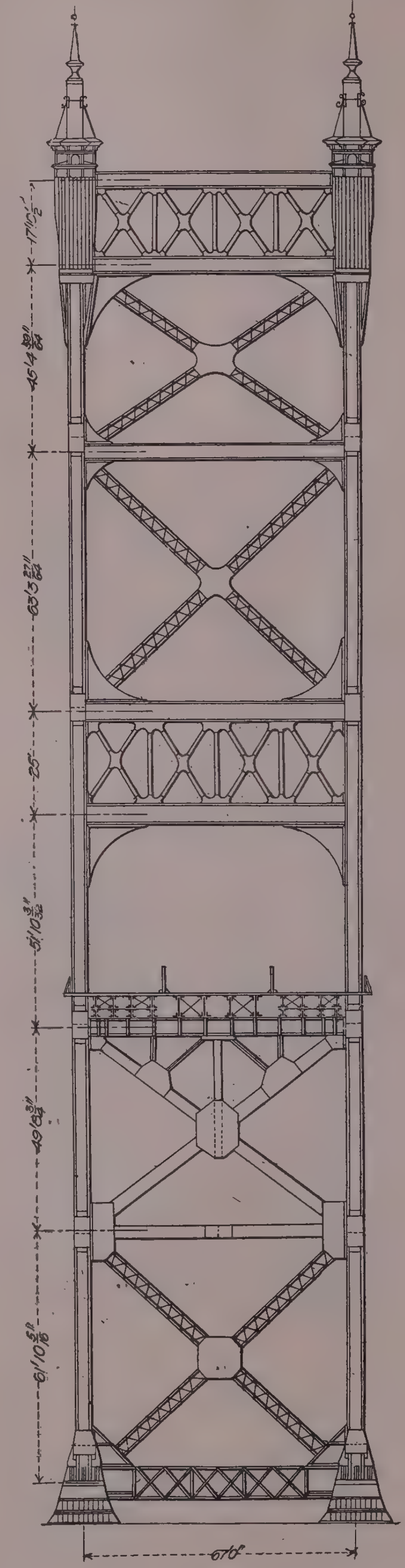
The Quebec Bridge Superstructure Details.—I.

Vertical Bent on Main Pier.—The total dead and live and wind loads plus anchorage reaction for 2,800 ft. of continuous trusses of the Quebec Bridge (see Eng. Record of Dec. 1, 1906) are carried by the two main piers through the vertical transverse bents over each. These bents are practically two trusses 315 ft. long and 67 ft. deep on centers and weigh 3,000,000 lb. each, an amount more than equivalent to the average weight of a double-track railroad span 350 ft. long. The trusses are seated on large and high pedestals which transmit the total load of about 56,000,000 lb. to the masonry on which it is distributed so as to reduce the unit pressure within the required limits.

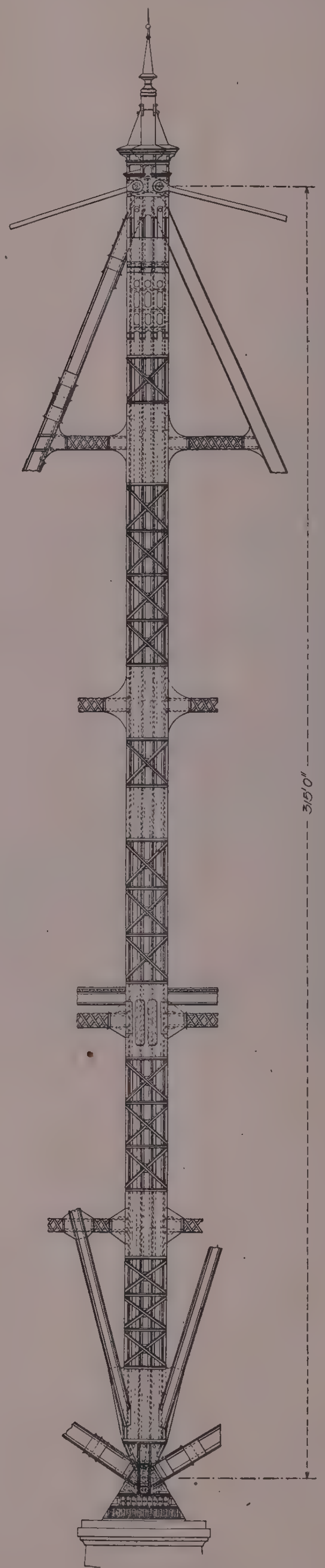
The pier tops are about 50 ft. above low water and the upper ends of the vertical posts being extended nearly 42 ft. above their top pins by ornamental finials reach to a height of over 400 ft. above low water. The vertical posts are connected by deep latticed girders, transverse struts, I-bracing and kneebraces, which with them form a complete truss of five panels perfect in every respect, except that in the center panel the diagonals are omitted to provide clearance for the railroad tracks.



Bolster Details.



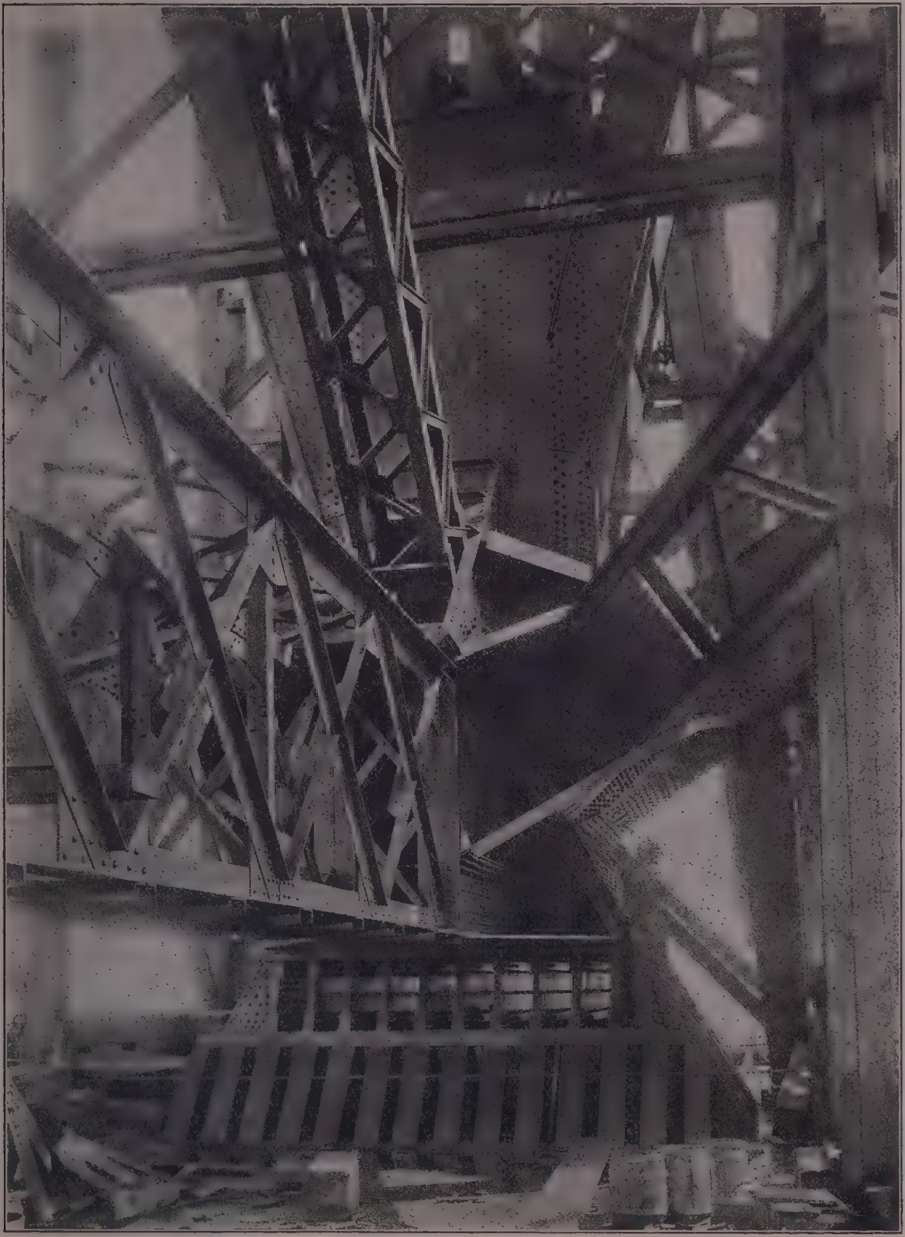
Main Tower Bent.



Main Post.

The transverse stresses carried through these portions of the vertical posts thus develop 1,796,000 lb. bending moment in each post, which requires an additional cross-sectional area of 104 sq. in, besides the 422 sq. in. required for the 10,132,000-lb. maximum stress composed of 1,616,000 lb. live load, 7,237,000 lb. dead load, 419,000 lb. snow load and 860,000 lb. wind load. The column sections are figured for a maximum unsupported length of 76 ft. and a unit compression of 24,000 lb. per sq. ft. is allowed. To sustain these enormous stresses the posts have a 4x10-ft. rectangular cross-section made with four built I-beams, containing sixteen 8x6x13/16-in. flange angles, eight 48x¾-in. web plates and sixteen 7x¾-in. flange reinforcement plates.

The posts are made in five main sections from 50 to 76 ft. long, exclusive of the short heavy top and bottom sections which are made and shipped separately for convenience in shop construction and erection. They are seated 10 ft. above the pier tops on riveted pedestals and bolsters of unprecedented dimensions and have field-riveted connections to the transverse and diagonal members. The tops of the posts are connected by a truss 18 ft. deep on centers with its top chord composed of a pair of plate girders



Bolsters and Connections at Foot of Main Pier.

52 in. deep having ⅜-in. web plates and pairs of 6x4x7/16-in. flange angles. The lower chord is similar except that the girder webs are only 48 in. deep. The diagonals are rigid members with I-shaped cross-sections made with pairs of angles back to back.

A similar truss connects them near their middle points, above the roadway, and is 25 ft. deep with its chords made with pairs of plate girders 60 in. deep. Three of the transverse struts consist of pairs of plate girders with webs from 36 in. to 48 in. deep, the third or bottom strut connecting the pedestals has an I-shaped cross-section 8 ft. deep and in reality amounts to a latticed girder with each flange made with 8x8x½in. angles latticed together with 4x4-in. angles.

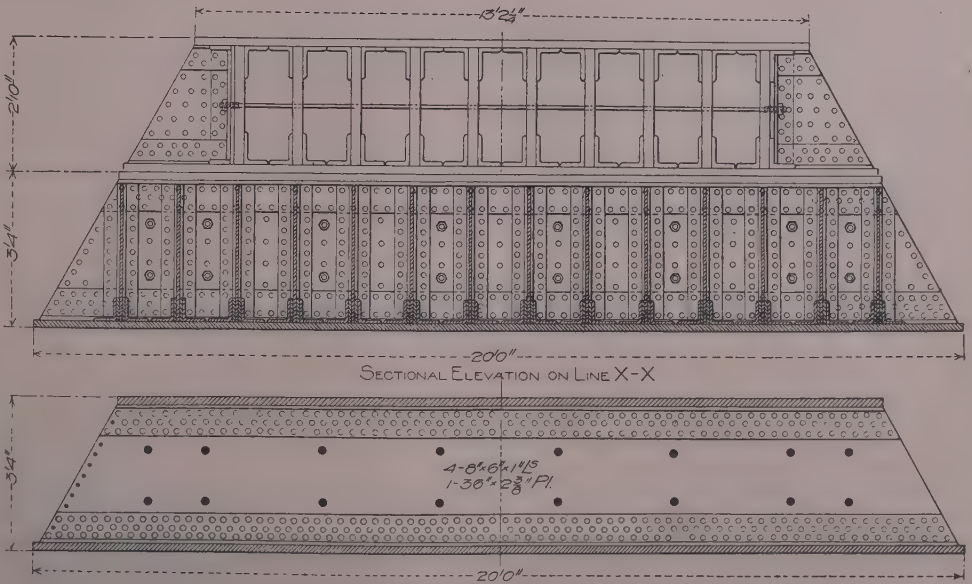
Another strut 121 ft. above the top of the pier is made with two plate girders 40 in. deep having their top flanges connected with a 48x½-in. cover plate and serving as a floor beam so braced to the special diagonal members in the panel below it that altogether they virtually form a sort of Fink truss about 25 ft. deep. In this panel the diagonal members have rectangular cross-sections made with two built channels having their flanges turned in and latticed. Each channel is made with a 36x7/16-in. web plate and two 6x4-in. flange angles. In the other panels the diagonal members have I-shaped cross-sections about 3 ft. deep made with pairs of 6x6x9/16-in. angles riveted together back to back and latticed. The diagonal members in all panels of this bent are cut to clear each other at intersections where they are connected by two very wide and thick field-riveted flange cover plates. In all members of this bent the latticing consists of X-braces made of small angles riveted together back to back and latticed. In all connections above the roadway level, the jaw-plates, gussets and all other connection plates visible have their exposed edges curved concave to give more graceful and attractive outlines to the structure.

Bolsters.—The shoes riveted to the lower ends of the vertical posts are pin-connected 10 ft. above the top of the pier masonry to riveted pedestals seated on two tiers of bolsters, which although made separately, really act as single members distributing the enormous load over an area of 360 sq. ft. and correspondingly diminishing the unit pressure on the cut granite masonry to 78,000 lb. per sq. ft.

The 18x20-ft. lower bolster is 40 in. high and is made with massive cap and base plates connected by eleven vertical ribs parallel to the bridge axis. It is symmetrical about the longitudinal and transverse center line and is separated on the former into halves manufactured and shipped separately and assembled in position at the site. In accordance with this construction the center longitudinal web is made double, each portion of it being about one-half as thick as the other webs, and fitting close together, face to face, as assembled in position. The halves of the bolster are fastened together by sixteen 1⅛-in. upset horizontal rods 13 ft. 3 in. long arranged in two horizontal courses which pass through 1⅞-in. holes in all webs and have nuts at both ends screwed up to solid bearing on the outer faces of the outer webs.

The dimensions of the 9x20-ft. base plate 2 in. thick were practically limited by the sizes rolled in the plate mill and the 36x2½-in. web plates were so large that it was necessary to cut them with a cold saw, the ordinary shears being inadequate to the service. The 6x8-in. flange angles are 1 in. thick and all rivet holes were drilled from the solid. The beveled ends of the ribs were accurately spaced and the top and bottom flanges were planed to insure perfect bearing against the base and cap plates which were themselves planed on both surfaces.

The webs are so massive that it was not considered essential to connect them by transverse diaphragms, but those on the outside of the bolster were each stiffened with 14 triangular full height diaphragm frames ¾ in. thick. The bolster weighs 155,000 lb. and is secured to the masonry by thirty 1⅝-in. bolts 72 in. long through 2-in. holes close to the outer edges of the base plate. To provide for an even distribution of the enormous pressure over the granite coping of



SECTIONAL ELEVATION ON LINE X-X

SECTION OF LOWER BOLSTER ON LINE Z-Z

Bolster for Main Post.

the pier the base plate is seated on two thicknesses of No. 1 cotton duck very carefully sewed together to avoid overlap at the edges and saturated with boiled linseed oil and red lead.

The upper part of the bolster corresponds with the lower part and together they make the frustum of a rectangular pyramid 74 in. high with an 18x20-ft. base and a 13-ft. 2¼-in.x11-ft. 9-in. top.

(To be Continued.)

Method of Deriving Quantities Directly from a Profile with a Planimeter.

The simple method of deriving directly from a profile by means of a planimeter the quantities of materials to be moved in excavating trenches is used in the office of Burns & McDonnell, consulting civil and sanitary engineers, of Kansas City. The usual method employed in computing quantities in trench excavation from a profile when a planimeter is used is to divide the profile into sections, each of which can be covered by the planimeter, to derive the area of each of these sections with the latter and then multiply this area by the width of the trench and divide the quantity thus found by 27 to reduce it to cubic yards, as profile dimensions are usually in feet. The method that has been devised to derive quantities directly from the profile with the planimeter is as follows: The area of the guide disk of the planimeter in square inches is known for each particular instrument and represents so many square feet on the profile. By experiment the position of the pointer on the bar of the planimeter which will give the quantity of material in the section of the trench covered on the profile by the pointer is determined for each width of trench; the pointer is set in this position and the quantities for different sections of the profile are read directly from the vernier of the planimeter.

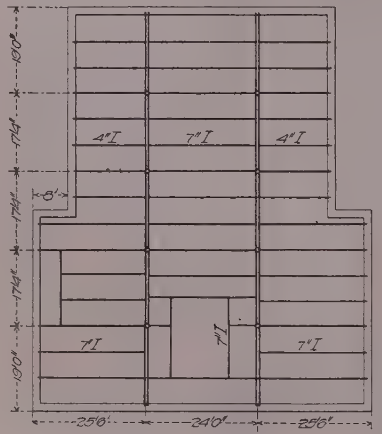
Table Showing Values on Graduated Arm at Which to Set Pointer for Different Widths of Trench.

Width of Trench, ft.	Setting of Graduated Arm.	Value of Unit on Vernier.
2.00	216.2	2 cu. yd.
2.25	231.7	2 "
2.50	129.6	1 "
2.75	150.5	1 "
3.00	168.5	1 "
3.25	183.0	1 "
3.50	195.5	1 "
3.75	206.5	1 "
4.00	216.2	1 "
4.25	224.3	1 "
4.50	231.7	1 "
4.75	238.3	1 "
5.00	129.6	½ "
5.25	140.0	½ "
5.50	150.5	½ "
6.00	168.5	½ "
6.50	183.0	½ "
7.00	195.5	½ "
7.50	206.5	½ "
8.00	216.2	½ "
8.50	224.3	½ "
9.00	231.7	½ "
9.50	238.3	½ "
10.00	129.6	¼ "
10.50	140.0	¼ "
11.00	150.5	¼ "
11.50	160.3	¼ "
12.00	168.5	¼ "
12.50	176.2	¼ "
13.00	183.0	¼ "
13.50	189.8	¼ "
14.00	195.5	¼ "

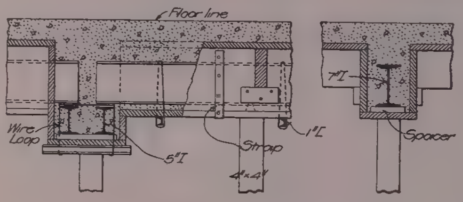
For horizontal scale, 1 in. = 100 ft.; vertical scale, 1 in. = 10 ft.

As an example, assume a profile to be platted to a horizontal scale of 100 ft. to 1 in. and a vertical scale of 10 ft. to 1 in., and the area of the guide disk of the planimeter to be 4 sq. in. Then 1 sq. in. on the profile represents 1,000 sq. ft. of transverse section of the trench and the area of the guide disk of the instrument represents 4,000 sq. ft. of area on the profile, which for a trench three feet wide would represent 444.4 cu. yd. By trial it is found that one revolution of the guide point on the guide disk would, for a trench 3 ft. wide, represent 444.4 cu. yd. of material to be moved, requiring the instrument to be set at 168.5 on the graduated arm in order to give a reading of 444.4 on the vernier wheel. That is, by setting the graduated arm at 168.5 the quantity of material in any section of a 3-ft. trench profile may be read in cubic yards directly from the vernier of the planimeter.

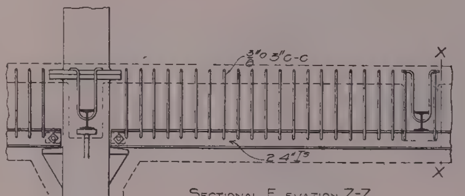
The accompanying table shows the values at which to set the graduated arm for different widths of trench platted on a scale of 10 ft. to the inch vertically and 100 ft. to the inch horizontally, with the instrument used by Burns & McDonnell. These values must be determined for each instrument separately. These determinations can be made in a short time, however, and the values once found are always available.



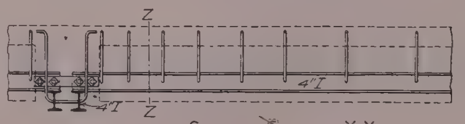
Beam Plan.



Beam Moulds.



Sectional Elevation Z-Z



Sectional Elevation X-X

Reinforcement in Beams.

With a little care in finding these values, results in cubic yards which are entirely accurate can be read directly from the profile with the instrument.

A Phenomenal Rainfall was reported at a recent meeting of the Meteorological Society of London by Mr. R. L. Holmes. It occurred at Suva, Fiji, and unfortunately the exact amount of the precipitation had to be estimated, because the observer failed to measure the fall at frequent intervals during the night. The rain occurred on Aug. 8, 1906, very little precipitation occurring until 6 p. m., when there was a ceaseless downpour until sunrise of the next day. At 10 p. m. the assistant observer found the rain gauge overflowing with 12.5 in. of rain in it. Four hours later the gauge was again overflowing, and 6 a. m., it was overflowing once more; that is, it overflowed three times in 12 hours. Very little rain fell after 6 a. m. The gauge was 25 ft. above ground, and the measurements show that the fall was at least 37 in., while Mr. Holmes believes that it was probably about 11 per cent. greater than that amount.

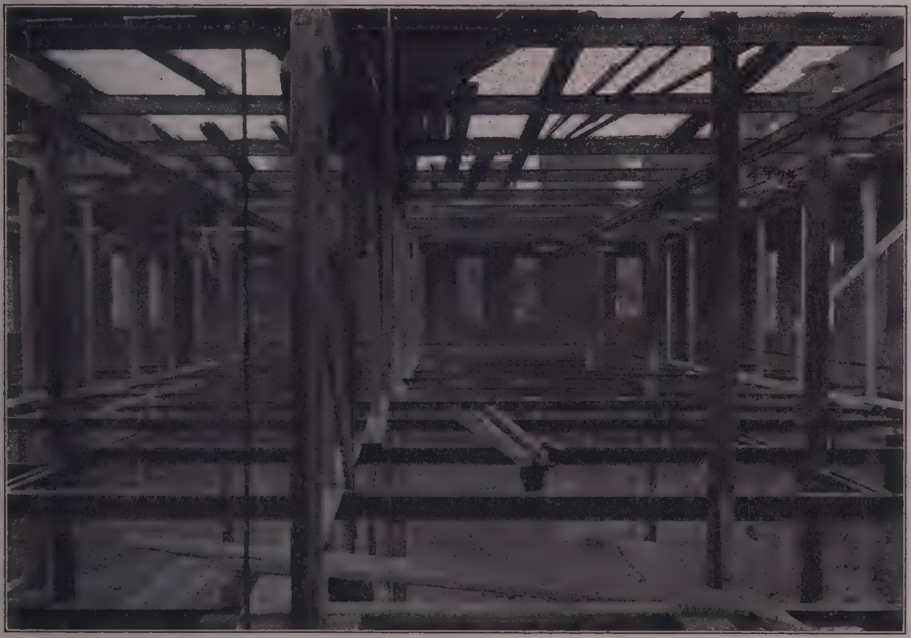
The Salvation Army Building, New York.

The Salvation Army Building on West 48th St., New York, is a 75 x 90-ft. six-story fireproof structure with circular cast-iron columns fire-proofed with concrete and wire lath jackets, and reinforced concrete floors and roof. The self-supporting exterior walls are of brick from 24 to 16 in. in thickness according to the requirements of the building law. They carry the outer ends of the floor beams and girders and were constructed simultaneously with the erection of the columns.

The columns are of the ordinary type used to support steel beams and girders; the finished beams and girders in floors and roof are of reinforced concrete construction and there are no steel beams or girders calculated to carry live loads. The reinforced concrete floor and roof construction is of a special type, recently adopted by the contractors and has been designed to combine the erection features of steel cage construction with the permanent functions of reinforced concrete members. As fast as the walls and columns were carried up, tiers of very light permanent beams were connected to them in the successive floors to form a complete skeleton frame-work with sufficient strength to brace the columns and carry the whole or a large part of the dead weight of the floors and roof. The light I-beams were entirely inadequate to alone support the working loads of the finished building. They were arranged and proportioned to carry the concrete and false-work during erection and afterwards they served as the permanent reinforcement for the concrete with sufficient cross-section to provide for the stresses in the different members where the compression stresses are taken up by the concrete which gives mass and rigidity to the members and protects the steel work.

The columns are arranged in two longitudinal rows 24 ft. apart and vary from 8 in. diameter and 1 in. thick in the upper story to 12 in. diameter and 1¼ in. thick in the basement. The columns are connected by pairs of longitudinal I-beams and by single transverse I-beams which with intermediate transverse beams divide the floor into panels of a maximum size of 5 ft. 10 in. x 24 ft. Above the first floor the longitudinal girders have pairs of 5 in. 9¾-in. I-beams and the transverse beams have single 7-in. 15-lb. I-beams except in the short panels where 4-in. 7½-lb. I-beams are used. The lower story is used for a stable and its floor, which provides for a live load of 200 lb. per sq. ft., has pairs of 7-in. 155-lb. I-beams of 17-ft. 4-in. span in the longitudinal girders, and single 8-in. 18-lb. transverse I-beams of 24-ft. span. In the upper stories the live floor load is 120 lb. per sq. ft., and the longitudinal girders have a uniform width of 12 in. and a depth of 23 in., including the thickness of the floor slab. The I-beams embedded in them 2 in. clear of the lower surface provide a net cross sectional area of 5.7 sq. in. for the maximum tension stress of 90,000 lb. where the 250 sq. in. of concrete included in the girder and adjacent portion of the floor slab provide for the 500-lb. maximum compression stress. Similarly the 8 x 18-in. transverse floor beams 24 ft. long and 5 ft. 10 in. apart have 100 sq. in. of net cross section of 1:2:4 concrete made with Alpha Portland cement and 1 in. gravel.

The double I-beams in the longitudinal girders are spaced about 3 in. apart in the clear and from them double U-shaped loops of No. 10 iron wire are suspended about 4 ft. apart. The lower ends of the loops engage short horizontal transverse pieces of 1-in. channels which thus form suspended bearers to carry the 12-in. wide bottom planks of the girder moulds. Longitudinal vertical side boards 20 in. high are nailed to the edges of the bottom boards and carry the ends of the bottom boards for the moulds of the transverse beams, the intermediate portions of the boards being suspended from the beams themselves with double loops and channel bars as described for the girders. The side pieces of the moulds for the transverse beams are built up to the floor slab level and are additionally secured by outside bent straps of 3/32 x 1½ in. iron 3 ft. apart on centers which are screwed to the boards. The side pieces for the girder moulds were built up between the transverse beam moulds and the longitudinal boards forming the centering for the floor slabs were laid on the upper edges of the beam and girder moulds, thus completing the falsework which was entirely suspended from the beams and girders. The wire suspension loops are twisted until they draw the moulds up close against triangular transverse spacing strips 1 in. thick, inserted about 6 ft. apart under the lower flanges of the beams. In order to prevent the undue deflection the beams and girder moulds were intermediately supported with vertical 4 x 4-in. shores about 6 ft. apart. The I-beams being bolted rigidly in place with standard connections and having regular cross sections with ample clearances around them could not become displaced in the mould and afforded plenty of clearance for the concrete filling, so that it was easy to prevent the occurrence of any voids and to insure the accurate position of the reinforcement in the finished beams.



Self-Supporting Reinforcement Steel for Beams and Girders.

All of the I-beams were cut from stock at the contractor's yard and the lengths were such that the weight of a single piece seldom exceeded 150 lb. and all could be conveniently handled by two men without the use of derricks or special hoisting apparatus. All of the wood used was ⅞-in. North Carolina pine planed on one side and edged, with the ends cut square. The moulds for the beams and girders were built complete and all floor boards were cut to length at the contractor's yard, thus entirely eliminating the necessity for carpenters at the building. The concrete was mixed in a Ransome machine and was distributed in wheelbarrows hoisted to the upper story in a barrel elevator. The work was done with a total force of 20 men who laid an average of about 3,000 sq. ft. of floor concrete daily, exclusive of work on the column fireproofing. The total floor and roof surface in the building comprises about 43,000 sq. ft. for which 15,000 ft. of lumber were used in the moulds. The original design called for 150 tons of beams and girders in the concrete floors. The revised design which was built as above described only required 60 tons of steel in the floors exclusive of the column weight which remained as originally designed.

In the original design of the steel work the cast iron columns carried 20-in. 80-lb. transverse I-beam girders of about 23-ft. clear spans and 10-in. 30-lb. longitudinal I-beam floorbeams of about 17 ft. clear span, spaced about 6 ft. on centers. The revised design left the cast iron columns as they were, but changed the girders from transverse to longitudinal and located the reinforced beams transversely, leaving the spacing of the columns exactly as originally laid out.

The contract was taken about Oct. 1, 1906, and, on account of the lateness of the season and the urgency of the work, the columns were left full-size and of cast-iron, as first designed in order to secure prompt delivery. Therefore, the reduction, in this case, in the cost of the steel work was in the floor systems. The original design had about 150 tons of steel beams and about 7 tons of fittings. The cast iron columns and bases weighed about 30 tons. In the system used there were about 60 tons of beams and girders and about 6 tons of U-bars. The bolts and anchors weighed only a fraction of one ton.

The centering for this class of concrete costs about 3 cents per square foot more than for the cheapest class of fireproofing. The saving over the cheapest class of fireproofing with the regular steel construction, as originally laid out, was estimated at $3,000, which was about 20 per cent. saving on the cost of the complete floors and columns; not including the outside walls or stairways, which remained as originally designed.

Steel beams and columns for the first tier were delivered on the job fifteen days after signing contract and the steel for the whole job was delivered about thirty days after signing contract. The erection of the steel work was done in the ordinary way, running the columns, girders and beams up ahead of the fireproofing. The roof was put on ahead of the two tiers underneath the same, so as to shut out snow, and the two floors under roof erected during the winter.

Mr. G. A. Pigeron was the architect, and Mr. W. H. Farrar, consulting engineer. The Standard Concrete Steel Co., New York, was the contractor for the floors and roof here described.

The details of the beams and girders in the Salvation Army Building correspond very closely, except for a slight variation of dimensions, with those for the V. D. Martin & Co. packing plant, Philadelphia, recently built by the same contractors. The views here given of the latter structure show the arrangement for a live load of 150 lb. per square foot on the typical 6 x 24-ft. panels, which is adopted whenever possible as standard for this type of construction. It will be noticed that the girder beams are web connected with the columns besides the support which they have on the column lugs, and that the transverse beams rest on their top flanges and are continuously connected across them with bolted web plates. All I-beams are punched through the neutral axis for ⅜-in. vertical U-bars spaced according to the shear diagram to sustain the vertical stresses.

The Salvation Army Building was erected during the unusually cold weather of last Winter without any injurious effects being noticeable upon the concrete. No especial precautions were observed in mixing or placing the concrete, but care was taken to maintain the moulds and shoring in position until water ran freely through the arch floor slabs.

The Chuviscar Dam Accident.

The Chuviscar dam accident near Chihuahua, Mexico, which was widely reported recently to have caused many deaths, turns out to have been an insignificant matter. The engineers and contractors for this work, Messrs. McQuatters, Trueheart & Co., of Chihuahua, were removing the sand in a deep hole only partially within the lines of the foundation of the dam, and it was necessary to brace one side of it to keep the sand out of the pit, the remaining three sides being formed by the natural rock walls. As it was impracticable to brace the sheeting against the rock walls, the thrust of the sand was taken up by a truss or buckstay, consisting of a 12x12-in. chord 56 ft. long, placed against the sheeting and braced by 6x4-in. posts 4 ft. long, having a ¾-in. cable stretched over their ends, thus forming a truss Owing to a shortage of material, it became necessary either to stop the work or proceed below the bottom of the sheeting with the excavation. As the gravel stood up well, the latter plan was considered feasible and a temporary system of sheeting was put in to prevent any sliding of the earth below the main sheeting. When the excavation had been carried down 8 ft. below the bottom of the main sheeting, one of the workmen carelessly excavated below the temporary braces which caused the 8-ft. provisional sheeting to fall in. While putting it back, the bank caved, causing a slide from behind the main sheeting, thus carrying all of it down. When it fell one of the 12x12-in. beams struck a foreman and killed him, but this was the only fatal accident. Three men were injured by the falling timbers, but have since fully recovered. The excavation was subsequently carried to a depth of 116 ft. below the original surface of the ground at this place, and concrete is now being laid in it at the rate of 150 cu. m. per day.

TWO UNUSUAL CHAIN DRIVES have recently been furnished by the Link Belt Co., both of them being of the Renold silent type. One installed to transmit 325-h.-p. to refrigerating machinery in a brewery, consists of a pair of parallel chains on pulleys 14 ft. apart, running at 1,100 ft. per minute. The second drive runs a centrifugal pump from a horizontal turbine; its pulleys are 11 ft. 7 in. apart, the speed is 1,755 ft. per minute and the capacity of the chain is rated at 225 h.-p.

A Slow-Sand Filtration Plant and Other Water Works Improvements at Denver, Colorado.

The Denver Union Water Co., which furnishes the City of Denver with water, has recently added to its slow-sand filtration plant three filters, having a net filtering area of ten acres, and has made a number of other important changes in its system. About 75 per cent. of the water supply of Denver is obtained from the South Platte River, the balance being taken from tributaries of that stream, known as Cherry Creek and Bear Creek. For convenienec of operation the water works system has been divided into three divisions, designated, respectively, the mountain, river and city divisions. The mountain division embraces all the property leased, or owned, by the company south of Platte Canon, a station twenty miles south of Denver on the South Park branch of the Colorado & Southern Ry. The river division embraces all the property controlled by the water company between headgates on the South Platte River near Platte Canon, and the southern limits of the city of Denver. This division includes three conduits which supply water to distributing reservoirs located in Denver. The city division embraces all the property owned and controlled by the water company north of the southern limits of Denver.

Lake Cheesman, which is included in the mountain division, is a large storage reservoir, about 50 miles from Denver on the south fork of the South Platte River, the site of this reservoir being immediately below the junction of Goose Creek with that fork. The dam which impounds the water contained in Lake Cheesman is constructed of granite, obtained near the site and has a total height of 222 ft. from the bed of the stream to the crest of the spillway. The design and construction of this dam, which is believed to impound the greatest depth of water of any that has yet been built, were fully described in The Engineering Record, for October 24, 1903.

Water can be drawn from the lake through the dam at three levels and passes through tunnels excavated in the native rock. The three tunnels connect with a single outlet tunnel, having a cross section of 6x9 ft. The lake has an area of 874 acres and contains very nearly 30,000,000,000 gal. of water when filled to spillway level. The lowest level at which water can be drawn from the lake is 15 ft. above the bed of the stream. The area of the water at this elevation is 27 acres, and below this level there are 29,000,500 gal. of water stored.

During the years 1903, 1904, 1905 and 1906 the total rainfall recorded at the dam was 59.89 in. Assuming this to be the average amount for the water-shed tributary to the reservoir, calculating the amount of water stored during that time, and allowing for the amount of water that passed the dam, the amount of run-off for the water-shed is practically 6.51 per cent. of the rainfall.

The slow-sand filtration plant of the system is at Platte Canon, about 27½ miles below the Cheesman dam. At a point three miles above Platte Canon are headgates, where a diverting dam consisting of loose rock and earth is constructed, these gates being removed and replaced from time to time, dependent upon the amount of water flowing in the river. From the headgates water can be drawn through a 30-in. conduit, nearly 3 miles long, which discharges into a reservoir at Platte Canon. This reservoir is used as a sedimentation basin, and has a storage capacity of 300,000,000 gal., the height of the spillway being 360 ft. above the Denver city datum. As shown on the accompanying plan, the reservoir is on the east side of the river and about half a mile below the filter beds. Provision is also made for supplying water to it from a large flume that starts at the river at a point about a mile below the headgates, and parallels the eastern bank. If desired, water from the 30-in. conduit taken through the headgates can be delivered at Platte Canon into a 34-in. wood-stave conduit, leading to two basins in Capitol Hill, in the eastern portion of Denver, which supply the distribution mains for a portion of the city. The supply is seldom delivered in this manner and when it is the water is passed through a mechanical filtration plant instead of passing through the slow-sand filters. This mechanical filtration plant is below the filter beds at Platte Canon, and about two and one-half miles nearer the city.

Water can be drawn from the large sedimentation basin at Platte Canon into two smaller sedimentation basins above the filter beds. These smaller basins cover an area of seven acres and are built partly in excavation and partly in embankment, with 7 ft. as the nominal depth of water. The bottoms of the basins are not paved, but the inner slopes are paved with hand-laid rip-rap. Water can also be supplied to these basins through a flume, which receives its supply from the river at a point about 1,000 ft. to the south.

Immediately adjoining these sedimentation basins on the north are the filters, three of which have an area of 2½ acres each. Space for a fourth filter of the same size was held in reserve until recently, when three filters of equal capacity were built on it instead of a single one covering two and one-half acres.

Partly Placed Underdrains in One of the New Denver Filters.

The arrangement of the two sedimentation basins and adjoining filters, as shown on the accompanying plan, is such that water is discharged by gravity from the sedimentation basins into and through the filters. The sedimentation basins and filters are all approximately rectangular in shape, and are placed in two rows, with one sedimentation basin to five acres of filtering area in each row. The two rows are separated by a driveway on top of the diverting embankment between basins and filters.

The filters are partly in excavation and partly in embankment. Their bottoms are lined with 6 in. of concrete, which is laid in alternate blocks 7 ft. square, with true joints between the blocks. The inner slopes of the embankment around the filters are lined with 6 in. of concrete, laid in strips 7 ft. in width. The space originally designed for the fourth filter has been divided into three filters by concrete walls, 10 ft. high, 2 ft. wide at the top, and 4 ft. wide at the base. These walls were constructed in sections 16 ft. in length, with true joints between contiguous sections.

The plan of the supply, effluent and drainage piping for the three new filters is shown in an accompanying illustration. The under-drainage system for these filters is quite similar to that of the three original larger ones. The outlet for each sedimentation basin is at the inner downstream corner of the basin, and consists of a 36-in. pipe connecting with a gate chamber built into the embankment between the two basins. A 36-in. supply main is laid from this chamber along the embankment between the two rows of filters and is extended northward to connect with a 36-in. wood-stave discharge pipe from the Platte Canon reservoir. The filters can thus be supplied with water from the small sedimentation basins, or from the Platte Canon reservoir. Inner connections with this 36-in. supply main are equipped with regulating valves in gate chambers.

A second gate house near the dividing embankment and in the downstream side of the filter known as No. 2, receives the effluent from filter No. 1 through the embankment and also from filters Nos. 2 and 3 through an effluent pipe which is laid under filter No. 2 for its entire length. A gatehouse in the division wall between filters Nos. 4 and 5 contains all the required valves for regulatng the effluent from those two filters, and a third gatehouse regulates the effluent from filter No. 6.

The filtering material has a maximum depth of 48 in., consisting of 12 in. of gravel at the bottom, over which is placed 36 in. of sand. The gravel was graded into three sizes: the lower 7-in. is composed of stones that passed a 3-in. screen and were retained on a 2-in. screen. This grade is overlaid by 3 in. of stones that passed a 2-in. screen and were retained on a ¾-in. screen; above this are 2 in. of gravel that passed a ¾-in. screen, and were retained on a ⅜-in. screen. The sand was taken from the river bed, and before being placed in the filter was thoroughly washed and graded to an effective size of 53 mm., having a coefficient of uniformity, ranging from 2 to 2.5.

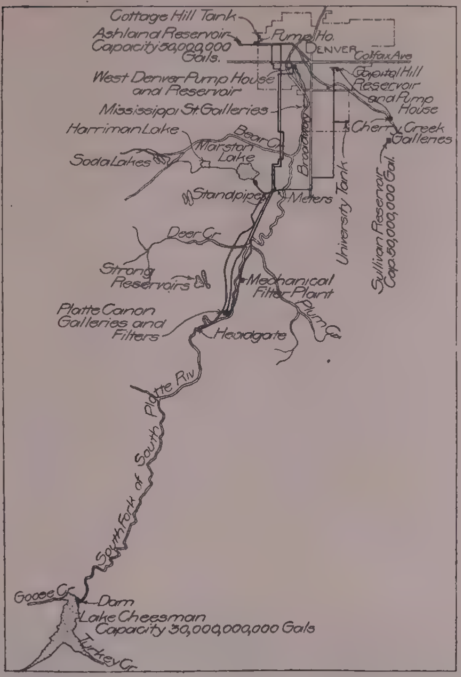
The under-drainage system of these filters consists of a main collector of vitrified pipe, which is laid along the longitudinal center line of the filter in a slight depression made in the bottom lining of the latter. This main collector has 6-in. lateral drain pipes, also of vitrified pipe, which are laid with open joints and are perforated with ⅝-in. holes. These lateral drain pipes are 15 ft. apart on centers. They extend to within 7½ ft. of the toe of the embankment and the division walls, where their outer ends are connected by piping which joins with the main collector and forms a ring system of under-drains.

The main collector of the three smaller filters, Nos. 4, 5 and 6, connects through gate chambers with a 30-in. effluent pipe, which is laid along the toe of the embankment in filter beds Nos. 4 and 5, and leads through the embankment at the lower end into filter bed No. 3. The flow of water through the inlet pipes is controlled by hand-regulated valves, as is also the outflow from the filter beds. Provision has been made in the arrangement of the pipe in the several effluent chambers, or regulating houses to install automatic regulating devices, but it is probable that these never will be placed as originally planned. It is expected that Venturi meters will be connected with the main collectors at their entrance into the gate houses, and the amount of effluent will be controlled by hand-regulated valves.

A 40-in. main receives the combined discharge from the several filters and extends to the city, where it is connected at different points with the distribution mains.

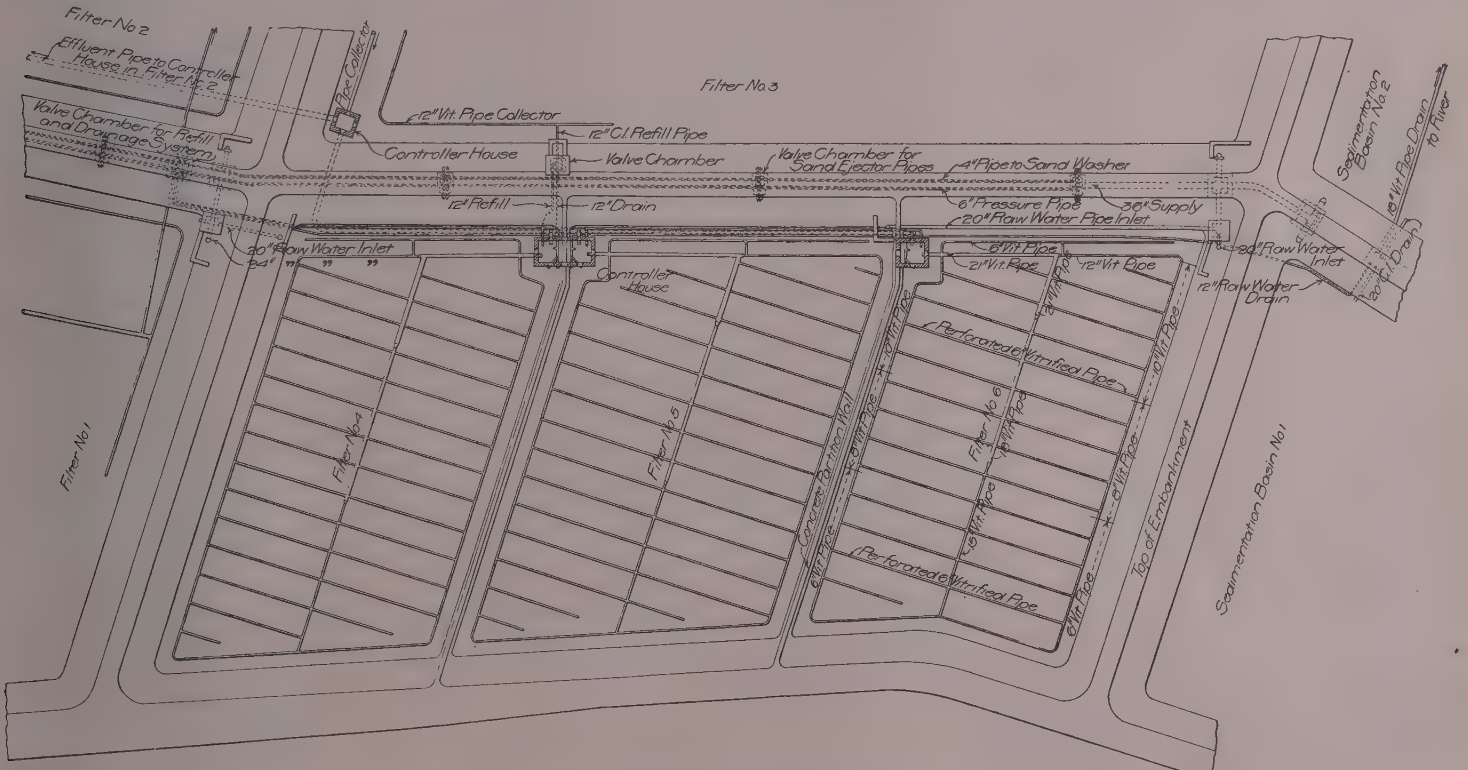
Each filter bed has an overflow in its outer gate chamber, which connects with the system of drains that extends to the river. Water can also be drawn from the surface of the filter beds through a connection in the inlet wall with this drainage system. The filter beds are all interconnected by a system of piping in such a manner that any one of them after being cleaned may be refilled through its underdrains with filtered water taken from other beds.

The dirty sand is scraped from the surface of the filter beds by hand and delivered into portable hydraulic ejectors, which are connected with a system of sand transporting pipes. This system of pipes is supplied with water by a duplex steam pump located in the power house, which operates against a water pressure 125 lb. per square inch. The dirty sand is conveyed through an underground piping system to a sand washer of the usual type, consisting of hoppers with hydraulic ejectors in the bottom. This sand washer is located at the end of the filter beds, near a power station that has been erected there. The washed sand is stored in a concrete court until the bed requires the sand to be replaced, when the process of transporting the sand is reversed, the ejector being placed in the court and the sand conveyed by water under pressure to the filter beds. The sand is allowed to accumulate in piles in the filter beds and from these piles it is wheeled in barrows and distributed over the sand bed. The results thus far obtained by this method have been entirely satisfactory.


Cottage Hill Tank
Ashland Reservoir Capacity 50,000,000 Gals.
Pump Ho.
DENVER
Colfax Ave
Capitol Hill Reservoir and Pump House
West Denver Pump House and Reservoir
Mississippi St. Galleries
Harriman Lake
Bear Cr.
Marston Lake
Soda Lakes
Broadway
Cherry Creek Galleries
Standpipe
Meters
University Tank
Sullivan Reservoir Cap. 50,000,000 Gal.
Deer Cr.
Strong Reservoirs
Mechanical Filter Plant
Plum Cr.
Platte Canon Galleries and Filters
Headgate
Platte Riv.
South Fork of South Platte
Goose Cr.
Dam
Lake Cheesman Capacity 30,000,000,000 Gals
Turkey Cr.

Map of Denver's Water Supply System.

Two and one-half miles downstream from Platte Canon is a mechanical filtration plant, having a capacity of 10,000,000 gal. per 24 hr., which has been out of service since the enlargement of the slow-sand filtration plant. This mechanical filtration plant received its raw water from Platte Canon reservoir, or from the headgates above the filter beds at Platte Canon, by gravity. The difference in the elevation between the high water



General Plan of New Filters at Platte Canon.

The Filters of the Platte Canon Plant of the Denver Water-Works.

in Platte Canon reservoir and the mechanical filtration plant is about 35 ft. In order to dispense with the mechanical filtration plant and to carry filtered water into the city through the same main supplied heretofore by that plant, it was necessary to raise the water supplying this main above the level of the filtered water in the effluent main from the slow-sand plant at Platte Canon, which is accomplished by a pumping station installed at the latter. Formerly the water conveyed from Platte Canon reservoir to the filter beds has been throttled by valves, as the high water in Platte Canon reservoir is 35 ft. above the highest filter bed. Advantage has been taken of this available power by installing in the station an 80-h.-p. water turbine consisting of two 15-in. standard capacity cylinder Victor gate wheels on a single shaft which is direct-connected to a shaft carrying two 12-in. Case De Laval centrifugal pumps, the water being passed through the turbine before reaching the filters. The centrifugal pumps draw water from the filtered-water main at an elevation of 314 ft. above Denver city datum, and discharge it into the main supplied by the mechanical filtration plant under a head, equivalent to 43 ft., or at an elevation of 357 ft. above Denver city datum. A 75-h.-p. De Laval steam turbine connected through a friction clutch to the shaft on which the water turbine and the centrifugal pumps are mounted makes it possible to operate the pumps either by water or steam power. With the water turbine driving a pump, the latter discharges water against a head of 43 ft. at rates varying from 3,500 to 7,000 gal. a minute. The speed of the pump does not exceed 1,350 r. p. m. when discharging 7,000 gal. per minute. With the steam turbine driving the pump, the speed of the latter does not exceed 1,450 r. p. m. when delivering 5,000 gal. of water per minute.

In addition to this unit there have also been installed in this power station a second unit consisting of a 10-in. Case De Laval centrifugal pump directly-connected to a 30-h.-p. De Laval steam turbine, the pump delivering 2,000 gal. of water per minute when operating at 2,000 r. p. m.; and a third unit consisting of a 12-in. Case De Laval centrifugal pump direct connected to a 55-h.-p. De Laval steam turbine, the pump of this unit delivering 3,500 gal. per minute when operating at 1,500 r. p. m.

The filter beds and buildings at Platte Canon are lighted by electricity, furnished by a 15-kw. 230-volt direct-current Sprague Electric generator direct-connected to a steam turbine, the unit operating at 300 r. p. m. The exhausts of all of the machinery operated by steam turbines are connected with a Wheeler surface condenser, through which all the water pumped by the several units passes. Steam is supplied to the machinery in this power station by two 132-h.-p. Babcock and Wilcox water-tube boilers.

A system of underground wooden galleries, comprising about 4,000 linear feet, and having a cross section 2½ feet square is laid under the bed of the river near Platte Canon. These galleries furnish about 7,000,000 gal. of water per 24 hr., which is conveyed through a 30-in. conduit to elevated distribution reservoirs within the city limits, a portion of the city being supplied from these reservoirs.

The following conduits are in service to convey water from Platte Canon and the headgates to Denver: the 34-in. conduit which takes water from the headgates at the diverting dam; the 40-in. conduit which conducts the effluent from the slow-sand filters at Platte Canon; and the 30-in. conduit which delivers water from the underground galleries.

About 12 miles southwest of Denver is a storage reservoir of 6,000,000,000 gal. storage capacity, known as Marston Lake, which receives its supply from Bear Creek, through 7 miles of conduit and flume. The water from this reservoir passes through a mechanical filtration plant with a capacity of 10,000,000 gal. per 24 hr. The effluent from this plant is discharged through 7,100 ft. of 44-in. conduit, that connects at Wynetka with the three conduits delivering water from Platte Canon. Venturi meters are installed at the intersection of these conduits, recording counters for these meters being placed in a brick building near at hand.

Two other sources besides those mentioned furnish water to Denver, namely: galleries under the beds of Cherry Creek and the South Platte River. Cherry Creek drains about 400 square miles of territory and discharges into the South Platte River within the city limits. The galleries under its bed are located five miles southeast from the Capitol Hill reservoir, and consists of a 36-in. cement pipe which extends under the bed of the stream for a distance of nearly one-half mile, at an average depth of 15 ft. below the bed of the stream. This pipe line is laid with open joints, and discharges into a 36-in. conduit extending to the Capitol Hill reservoir, in which a gravity flow occurs. The supply from this source varies from 3,000,000 to 5,000,000 gal. per 24 hr. Wooden galleries having a cross section of 3 x 5 ft. extend under the South Platte River for a distance of about 1,200 ft. at Mississippi St., within the city limits. These galleries deliver through 15,000 ft. of 48-in. conduit to a reservoir of 12,000,000 gal. capacity, which is located at a pumping station in the western part of the city. The supply from this source varies from about 10,000,000 to 14,000,000 gal. per 24 hr. All of these underground galleries are operated at slight expense. They are built in the sandy gravel beds under the streams, and as the latter carry very little turbidity, the water obtained from the galleries is of excellent quality.

The information from which the foregoing notes were prepared was supplied by Mr. George T. Prince, chief engineer of the Denver Union Water Co.

The Anthracite Coal Production in Pennsylvania in 1906 amounted to 63,645,000 long tons, according to the figures just compiled by the United States Geological Survey. This is 5,694,000 tons less than that of 1905. During the year 3,846,000 tons were reclaimed from the old culm banks, a larger amount than in any previous year.

The Construction of the Trust Company of American Building, New York.

The Trust Company of America Building at 41 Wall St., New York, occupies a 61x132-ft. lot and has two stories below street level and 25 stories above it, reaching to a total height of 330 ft. above the curb. It is devoted entirely to office purposes, and is of advanced fireproof steel cage construction. The general description and equipment, the foundation and the details of the steel superstructure have been illustrated in The Engineering Record of October 20 and 27, November 3 and 10, 1906, and will be supplemented in this article by the description of the methods and operations for constructing the superstructure.

Lowering 30-Ton Foundation Girder.

As it was required to carry the new foundations through quicksand to a much greater depth than those of the adjacent heavy and tall old buildings it was necessary to secure the safety of the latter by underpinning them, which was accomplished without disturbing their tenants before the tenants in the building formerly occupying the present site were disturbed. The Wall St. sidewalk was replaced at night by a timber platform with a trapdoor through which machinery was lowered and installed in the sidewalk vault without interfering with the plant in the old building. Recesses were then cut partly through the walls of the adjacent buildings and in them sectional steel pipes 3 ft. in diameter were inserted and forced down about 70 ft. to the solid rock through quicksand, water and boulders by the Breuchaud method, using a pair of hand power, 60-ton, hydraulic jacks and excavating the material by workmen operating under pneumatic pressure. The cylinders were filled with concrete and wedged up against horizontal beams, thus carrying the wall on a series of long columns reaching to rocks. It was thought that the base of a tall corner pier carrying a 500-ton load was inadequate to sustain it if seriously reduced by cutting for the underpinning cylinders, and it was therefore reinforced by an extension to which a portion of the load was distributed by heavy steel girders before the underpinning was commenced. After the underpinning was completed the girders were taken off and the extra footing removed, leaving the old piers supported on the new cylinders carried down as before explained.

Work was commenced May 1, 1906, by the wrecking contractor, Mr. Byron R. Green, in demolishing the eight and nine-story buildings with heavy self-supporting masonry walls which previously occupied the site. They were torn down by the use of a large boom derrick seated on the roof at first and afterwards lowered as the structure was razed. It delivered the steel beams and other long and heavy materials directly to wagons in the street. Plaster and other debris were dumped through floor openings to the second story where they were wheeled to a platform over the sidewalk and discharged through an inclined chute to wagons in the street. The platform was of the ordinary timber construction spanning the sidewalk at a height of about 12 ft., where it had a waterproof roof to protect the pedestrians from drip, and above this a heavy timber deck with a capacity of about 1,000 lb. per sq. ft. enclosed on the three outer sides by a substantial solid board fence which practically enabled it to be used as a storage bin in the early stages of the work, and in the later ones as a receiving platform for masonry, and other materials.

Sinking Pneumatic Caisson Foundation Piers.

After the removal of the old building down to street level the contractors for the new structure placed a pile driver on the 15-in. I-beam girders of the first floor, and with it drove forty 40-ft. piles through the old cellar floor to form a trestle on the center line of the building carrying a 24-ft. gauge track from end to end of the building at street level. On this track a 29x29-ft. steel tower 30 ft. high was assembled and equipped at each corner with a mast 24 ft. long and a 50-ft., 8-ton steel boom; the traveler weighed about 20 tons and was equipped with four double-drum Ledgerwood hoisting engine and delivered to wagons in the street all of the old material below curb level, after which it handled the caissons and other substructure materials. The entire area of the lots was excavated by pick and shovel to a depth of about 38 ft. below the curb level or 22 ft. below water level, the soil being lifted in 1-yd. steel buckets by the traveler derrick and delivered by them to wagons in the street. When the wagons were not at hand to receive it, it was dumped into the bin over the sidewalk and afterwards into the wagons at convenience, thus preventing any congestion of materials or wagons.

In the superstructure there are 23 rectangular concrete piers carried down through earth, sand, quicksand boulders and water to the solid rock by the pneumatic caisson process. Fifteen of the piers are comparatively long and narrow and are arranged end to end around the three outer sides of the lot and with similar caissons of an adjacent building on the fourth side, completely enclose it and carry the wall columns. The remaining piers are smaller and are square and carry the interior columns. All of the caissons were built entirely of timber except for the steel cutting edge and are simple rectangular working chambers about 7 ft. high. With a single exception they were assembled complete at the contractor's yard, delivered to the building on trucks drawn by several teams of horses and were unloaded by the traveler boom which seated them exactly in their required position in the bottom of the excavation. The open tops of the caissons were covered by concrete slabs, built in position, and after these had set they served to support the upper parts of the concrete piers, which were built on them in temporary forms enclosing removable steel air-shafts. After they were carried up to a considerable height and had attained a great weight men entered the working chambers and excavated to bed rock under pneumatic pressure. The wall caissons were sunk with clearances of about 6 in. between their ends, in which opposite semi-circular shafts were cored out of the concrete. These shafts were connected by excavating the intervening material, the sides were sheeted and they were put under air pressure to exclude the water and enable the cutting edge to be reached, after which the cavity was filled with concrete, thus making a strong, watertight bond between adjacent piers. In one case a small caisson was sunk by hydraulic jacks reacting against cantilever girders anchored in an adjacent large caisson. The underpinning and the construction of the piers and vault walls up to the street level was done by the Foundation Co., who commenced operations July 17, and finished them October 15.

The steel superstructure weighs about 3,400 tons and was fabricated by the Carnegie Steel Co., and erected by the general contractors. It was erected by an average force of about 70 men, between October 18, 1906, and January 25, 1907. There are 27 lines of main columns made in two-story lengths, the rectangular closed cross-sections having maximum areas of 172 sq. in. They are generally connected by single 20-in. transverse I-beam girders which carry the 10 and 12-in. floor beams and have horizontal flange angle connections to the floor columns. The outer walls are supported at every story by special wall girders made of I-beams or of plate girders and provided in five transverse rows with detached or solid web kneebraces on the upper and lower flanges at both ends. The upper story columns over the banking room are carried by two double-web plate girders 47 ft. long and 7 ft. deep, weighing 40 tons each, and delivered in halves, assembled and riveted together in their final position. Otherwise the superstructure is very simple and regular and is made with units of moderate weights and dimensions.

The columns all have cast-steel pedestals transmitting their loads to grillages which distribute them over the tops of the concrete piers and reduce the pressure to the units permissible for this material. In one corner of the building two intersecting rows of columns are necessarily located on a line eccentric from the center of gravity of the large pier which supports them. Therefore in order to produce uniform pier loading the five columns are seated on two parallel girders which balance each other on the opposite extremities of the grillage beams. One of these girders, 37 ft. long and 7 ft. deep, weighing 31 tons, was riveted up complete in the shop and shipped as a unit to the building on a special truck drawn by 22 horses, which, notwithstanding extra wide tires, concentrated such heavy loads on the pavement that the latter was broken in several places. The girder, with its web horizontal, was lowered from the truck on to rollers made from 10-ft. sections of 4-in. pipe filled with concrete. It was moved forward clear of the sidewalk on a track supported by timber trestle bents about 12 ft. high seated on the basement floor beams. One end was lowered by the derrick, the other by a gallows frame, made with 12x12-in. timber. The fall lines from the tackles were led to the capstan heads of one of the hoisting engines, and the girder was lifted slightly to release the rollers and allow the trestles to be removed from underneath. It was then lowered to a new track laid on the basement floor and rolled on it to the head of an incline built to the sub-basement about 11 ft. lower. A preventer tackle was attached to it to control its descent, and after it arrived at the sub-basement it was rolled to position and the web was revolved 90 deg. into a vertical plane. During this operation its entire weight of 31 tons was momentarily carried by the boom of one of the derricks which had a nominal capacity of only 20 tons, but was not injured by this service. The companion to this girder on this same grillage weighs 36 tons, but is made with three webs which were shipped separately to the building and was handled easily by a single boom derrick which placed them as required before they were assembled and field riveted together.

All of the column pedestals were carefully set and leveled and then grouted to insure uniform bearing over the somewhat uneven upper flanges of the grillage beams. All beams and girders and the columns, which have maximum weight of 31,000 lb. and maximum length of 34 ft., were delivered by trucks at the 61-ft. Wall St. front and were handled by two mast and boom derricks which commanded the entire area of the building. The one nearest the street unloaded the trucks and either placed the materials where required or transferred them to the other derrick which stored or erected them. This involved some rehandling of the steel, but was so rapidly and systematically accomplished that no apparent delay was occasioned, and the work was carried forward with unusual rapidity. As much as three tiers, equivalent to about 170 tons, was erected in a single week. In order to secure perfect verticality of the framework 18 columns were securely guyed by longitudinal and transverse ¾-in. wire cables provided with turn buckles which kept them in position until the beams, girders and vertical wind bracings were assembled, which made the entire frame-work absolutely rigid. Some of the knee-braced connections had as many as 90 field-driven rivets. The field rivets were driven at the rate of about 300 per day by each of eleven 4-men gangs using Chicago pneumatic hammers operated by an Ingersoll-Sergeant steam driven compressor and by a Chicago electrically driven compressor, either of which had a sufficient capacity for the two, both being provided in order to guard against any delay through possible breakage. After the steel work was shipped from the shop some changes were made which involved the moving of one of the principal girders in the front of the building 4 inches inward and 3 in. upward, thus changing all connections in a large panel of the steel work. The ends of the intersecting beams and girders were cut off with a hacksaw and holes for new connections were made with Chicago pneumatic drills and reamers. In order to avoid so many new holes part of the connection was made with inclined bent plates engaging the old holes in both members, but these required so much fitting that it is doubtful if any advantage was gained by their use.

Each of the two wooden derricks has a 70-ft. mast and a 64-ft. boom operated by a double-drum, two-spool Mundy hoisting engine located in the sub-basement until the 17th tier had been erected, when they were moved to the basement to give clearance for the erection of the permanent machinery. The derricks themselves were moved, every second tier, by the usual method of disconnecting the boom and hoisting it with the mast used as a gin pole, then guying the top of the boom to make it serve in turn as a gin pole for hoisting the mast. This operation was accomplished by 8 men in an average time of three hours. When the derrick was shifted a flanged collar was attached to the boom in about 5 minutes and was provided with four rings through which the ends of ¾-in. wire guys were placed and clamped on the standing part of the rope to make connections, the other end being tightened by hand tackles. The mast was fitted with ten permanent ⅞-in. guy ropes, anchored in the upper end of the building, with the usual clamps and turnbuckles. Before the first tiers of steelwork were erected, the derricks, in their initial positions in the sub-basement, had their guy ropes attached to 6-ply loops of wire rope engaging short horizontal rails embedded for their anchorage in the upper part of the concrete piers. The mast and fittings weighed about 7,000 lb., and the boom and fittings weighed about 5,000 lb.

Bricklaying was commenced November 20 and finished March 15, with an average force of about 140 men. The walls contain about 3,500,000 common red brick and are faced in the sides and rear with 310,000 red pressed brick and 294,000 buff pressed brick. The front wall is faced with about 12,000 sq. ft. Vermont marble, cut and set by Mr. Edwin Shuttleworth, who commenced work November 15 and finished it March 15, with an average force of ten men. The marble was hoisted by a derrick as convenient, and stored in the adjacent stories, but work was not commenced setting it until enough was cut for the first four stories. Brick was delivered by wagons in the daytime and hoisted day and night, enough being kept on hand in the building for a 4-day supply.

The bricklayers worked on a continuous scaffold, 4 ft. wide, all around the building, suspended by 48 scaffold hangers about 8 ft. apart on centers, which were rented from the New York Scaffold Co. Each scaffold hanger had two cables wound on separate drums set in a light steel framework supported on cantilever I-beams which projected through the upper windows and were anchor-bolted at their inner extremities to the floorbeams and girders. The drum had a pinion engaging a worm gear on a horizontal transverse shaft bearing at one end a sprocket wheel operated by a rope descending to the platform. A small gang of laborers were kept constantly going around the exterior walls and operating the rope to raise the platform to keep it at approximately the same relative position so that the bricklayers worked without interruption and at nominally the same height, thus doing their work to the best advantage and making an effective economy of time and avoiding all erection or shifting of scaffolds. As the scaffold drums were only equipped with 100 ft. of wire rope it was necessary to shift them three times during the construction of the walls. The work was carried on uninterruptedly during periods of severely cold weather when the platforms were enclosed in canvas screens and salamanders were set inside in which coke fires were maintained, raising the temperature sufficiently to enable the men to work in comfort, and preventing the mortar from freezing before it set.

All floors are built with hollow terra cotta tiles furnished by the National Fireproofing Co., and covered with cement or terrazzo. Floor construction was commenced November 1st, and the 189,000 sq. ft. in the building were completed February 1st, with an average force of 6 men. There is approximately 532,000 sq. ft. of plaster in the building, which was commenced by Contractor H. W. Miller, on January 15, and was executed by an average force of 40 men, finishing it March 15. There is about 300,000 ft. of lumber in the rough carpentering, backs, sleepers, floors, etc., work on which was commenced December 30 and finished March 15 with an average force of 70 men. All wood used in the building was treated by the Electric Fireproofing Co. All outside window frames and sash were kalamined by Mr. John W. Rapp, and all side and rear windows were glazed with polished wire plate glass furnished by David Shuldiner. The trim for the 1,250 doors and 5,000 windows was furnished by the Batavia and New York Wood Working Company. Work on it was commenced February 15, and finished April 20, with an average force of 100 men. The plumbing and water distribution work was done by the Wells & Newton Co., who commenced about November 15th and finished April 20th, with an average force of 60 men. Steam fitting was done by Mr. L. H. Prentiss, who commenced November 1st and finished April 20th, with an average force of 50 men. Work setting the steam engines was commenced January 1st and the first ones were put in operation March 1st. The electric apparatus was installed by the Lord Electric Co., who commenced work November 15th and finished it April 20th, with an average force of 35 men. Work on the installation of the Vacuum Cleaner Company's system was commenced November 15th and completed March 1st. Six hydraulic elevators were installed by the Otis Elevator Co., who commenced work January 3d, and completed April 20th, with an average force of 20 men.

All partitions in the building are made with 4-in. hollow terra cotta blocks set in Atlas cement mortar. The exterior marble is set in mortar made with Meyers Puzzlona cement, each block being also carefully anchored either to the brickwork or to the steel structure. The wainscot in the corridors is of Italian marble furnished and set by the R. C. Fisher Co. The walls of the pent house are made with light structural steel framework filled with 4-in. hollow terra cotta blocks and covered with copper, which, together with that on the roof and on the bay-windows in the court above the eleventh floor was placed by Herman & Grace. The maximum number of men employed on the building at any one time was about 1,200, and all the work except that of hoisting was done in 8-hour day shifts. It is expected that the building will be ready for occupation in 325 days after the tenants left the old building, which is considered a remarkably short time.

Mr. Francis H. Kimball is the architect, Messrs. Purdy & Henderson are the consulting engineers, and the George A. Fuller Co. is the general contractor. Mr. John W. Braid, superintendent in charge.

A Railroad Fill Across a Marsh.

A railroad fill across a marsh on the Central R. R. of New Jersey caused unexpected trouble recently. It was proposed to put an earth fill about 500 ft. long across a salt marsh between Matawan and Keyport, N. J., and accordingly a timber trestle was built from which the filling material could be dumped. It was expected that there would be some settlement, and borings were therefore made to determine the depth of the soft mud, with the result that a hard earth stratum was encountered about 20 ft. below the surface of the marsh. There happened to be a quantity of discarded bridge timbers and old ties at hand, and these were laid over the surface to be covered by the fill, under the trestle and on both sides of it, in order to distribute more evenly the pressure of the filling material. The sinking at first was about what was anticipated and was uniform, but before the work had progressed far there was a sudden movement which resulted in displacing the trestle 14 ft. out of line and caused it to sink 7 ft. in a few hours. Indications were that the hard stratum reached by the borings was merely a crust, and that this had suddenly given way. This theory was later substantiated by the subsequent work, and the total sinking indicated that the solid earth was 45 ft. below the surface of the marsh. As the filling continued to sink, the soft muck was squeezed out to both sides, rising in places as high as 12 ft. above the original surface, and affecting the ground to a distance of about 200 ft. on each side of the trestle. The old timbers which had been laid on the marsh near the toe of the fill and at right angles to the trestle were forced down on the end toward the track, while the other end was raised by the muck which was squeezed outward. These timbers were gradually forced into a vertical position, and then the movement continuing the end which had originally pointed outward came to rest inclined toward the trestle. The fill has now been completed and the settlement has ceased. The total amount of filling was 60,000 cu. yd. about three times the quantity which would have sufficed if the solid stratum had been at the depth expected, 20 ft. below the surface.

Sawed Ties have been ordered by the Pennsylvania R. R. from the farmers and choppers who have heretofore supplied hewn ties. The reason for the change is a desire to prevent the enormous waste of wood in making hewn ties, despite the fact that it is generally conceded that the latter are less liable to decay than sawed ties.

General Method of Preparing Plans and Estimates for New York State Highways.

A description of the methods of conducting surveys for the State highway work in New York was printed in this journal on May 25. These methods were given in a manual issued by the State Engineer late last year, which also states the general method of preparing plans and estimates for such work, and from that pamphlet the following information has been obtained.

Working Plans are drawn from left to right on continuous-roll detail paper, 21 in. wide, to a scale of 50 ft. to 1 in. The transit or base line is plotted, checked and inked before plotting the details, which may be left in pencil. Names of streams, railroads, property owners, town lines and other data, which are to be copied on the official plans, are lettered neatly in pencil. Notes referring to soil, rock, walls, culverts and other data, which are not to be copied, are written. Magnetic north lines are drawn in pencil every 15 stations.

Working profiles are drawn on standard, continuous-roll, cross-section paper to a horizontal scale of 50 ft. to an inch and a vertical scale of 10 ft. to an inch. To avoid large rolls one-half the length of the profile may be plotted on the lower half of the paper and the remainder of the profile on the upper half. All profiles are checked and inked before drawing a new grade line, which may be left in pencil. The stations and elevations of all old culverts, bridges, railroad crossings, etc., are shown on the profile and all notes found in survey books regarding structures, soil, rock, intersecting highways, villages, etc., are written on at the proper place.

Cross-sections are drawn on standard, transparent, cross-section paper to a scale of 5 ft. to an inch, and are checked by reading back from the plot. The surface line, station numbers, elevations of center of present road, and abbreviations for walls, fences, tree lines, rock, etc., are inked after checking.

Grades.—Grade lines are drawn only after careful consideration of all the data available and are adjusted until the desired result is obtained. The following are carefully considered: 1, The distorted scale of the profile. 2, The relative importance of the road, the character of the traffic and the direction of heavy traffic, the maximum grade not necessarily being the same in both directions. 3, The character of the soil and old road-bed. 4, Drainage. 5, Houses, shade trees, intersecting drives., etc. 6, The recommendations of the inspection notes. 7, The avoidance, wherever practicable, of reverse grades on long hills.

It is considered desirable to place the new surfacing without breaking up the present traveled road-bed, and with as little filling as possible, if a reasonably smooth grade can be obtained by so doing.

Railroad grades with long tangents are considered to usually require unnecessarily expensive construction and are avoided unless certain to economically fulfill all requirements. Long fills are avoided wherever possible and no attempt is made to obtain material by long shallow cutting. There is no fixed limit in regard to the amount of excavation per mile, but careful adjustment of the grades usually keeps it between 2,000 and 3,000 cu. yd., or even less than 2,000 cu. yd. per mile.

The maximum grade is determined for each road separately and is referred to the Division Engineer, if one greater than 7 per cent. is necessary. Changes in rate of grade of more than 2 per cent. are eased by vertical curves 100 to 300 ft. in length, according to conditions.

Tangents are not less than 100 ft. in length, wherever practicable.

In places where doubt exists as to the proper position of the grade line a pencil note is made on the profile calling the attention of the engineer, who inspects the road, to the difficulty.

Care is taken in raising the grade at either side of a bridge or large culvert not to endanger the structure by closing flood channels.

Alignment.—The proposed new center line is drawn in pencil upon the working plan as soon as determined. A good alignment is considered essential; but, as in grades, long tangents are not necessary, and the radii or degree of curves need not be computed (except in an entirely new right-of-way), location being determined on the ground by offsets from the transit line.

Additional right-of-way is not taken, if the alignment can be suitably adjusted within the present limits, but sharp curves or angles, especially on or the the foot of steep grades, are avoided and right-of-way acquired there if necessary.

The increasing use of automobiles necessitates a straighter alignment than is required for ordinary traffic, especially on the main thoroughfares, such as the New York and Albany road. On roads of this kind all right angle turns or sharp bends are eliminated, unless situated in villages or places where the travel must of necessity be slow.

Road Surface.—Macadam, gravel or other road surfacing, rolled in place, is computed and estimated by cubical measure, deductions being made for all wooden floor bridges, railroad crossings, etc.

The width of the macadam varies from 8 to 16 ft. Under ordinary conditions 14 ft. is used as a standard width, 16 ft. being used on the most important highways or in villages, etc., and 12 ft. on the less important highways. Eight feet of macadam is used only on the least important roads.

The thickness of the macadam is 6 in. under ordinary conditions, but a greater or less thickness is used in special places to suit local conditions.

Maintenance stone is computed for macadam roads on the basis of 1 cu. yd. of ¾-in. stone for every 200 ft. of length of road, unless otherwise ordered by the Division Engineer.

Drives and intersecting highways are surfaced with ¾-in. stone on macadam roads, and an allowance of ½ cu. yd. for each drive, and 2 cu. yd. for each intersecting highway is made. On gravel, shale or other roads, no allowance is made for this purpose.

The width and thickness of the gravel surface are varied to suit local conditions.

Section of Roadway.—The width of the roadway is adjusted to suit local conditions. Under ordinary conditions the following widths are used as standard sections. For 12 ft. of macadam, 24 ft. between ditches; for 14 ft. of macadam, 26 ft. between ditches; for 16 ft. of macadam, 28 ft. between ditches. These widths are reduced in rock cutting or heavy grading, and are increased in villages or in a wide right-of-way, if this can be done without greatly increasing the cost. The standard widths are not reduced more than 2 ft. to keep within the present right of way, unless the cost of acquiring additional right of way is excessive.

Celluloid templates, cut to proper form and scale, are used to draw the section of the proposed improved road upon the section of the present highway. After adjusting the quantities and determining its final position the new section is drawn with red water color.

Slopes.—Side slopes in ordinary earthwork are drawn 1½ horizontal to 1 vertical. This may be varied somewhat according to the character of the material to be excavated.

Rock slope in cut is drawn ¼ horizontal to 1 vertical, and in fill, where no hand laying is intended, 1 horizontal to 1 vertical.

In earth fills, where the difference of elevation between the crown of the road and the toe of the slope is 4 ft. or less, the side slope is drawn 4 horizontal to 1 vertical.

Where the material for fills is borrowed from the sides of the road, the slope from the roadway is never less than 4 to 1.

Excavation.—The planimeter may be used in determining end areas. Regular excavation is computed from the cross-sections by the method of end areas. Culvert excavation is computed from the cross-sections, allowing 1 ft. outside of side walls and deducting the opening of present culvert, if any. Wall excavation is computed to a slope line of ½ to 1 from the lower back corner. Highway and drive excavation is computed from cross-section, allowing a bottom width of 20 ft. for highways and 12 ft. for drives.

Borrows are computed as follows: On roads where the total regular excavation exceeds the total regular embankment, but where a borrow is necessary in one or more sections, the regular excavation in the section is estimated to form three-fourths as much embankment; from this the total embankment in the section is deducted and 10 per cent added for shrinkage. Borrow is added to the total estimated excavation, but only the regular excavation and embankment appears in the list on the finished plans.

Embankment.—The planimeter may be used in determining end areas. Regular embankment is computed from the cross-section by the method of end areas. Culvert embankment is taken as 70 per cent. of the culvert excavation. Wall embankment or back fill is computed from the cross-sections. Highway and drive embankment is computed from the cross-sections, allowing a top width of 20 ft. for highways and 12 ft. for drives. An allowance of 2 cu. yd. of embankment is made for all timber and concrete ditch crossings.

Adjusting Quantities.—Under ordinary conditions excavation is expected to exceed embankment by 25 to 40 per cent., the excess being greater in shallow cutting than in deep cutting. On new locations the excess is expected to be from 35 to 50 per cent., according to depth of cuts and surface soil. In adjusting quantities the greater is reduced, wherever possible.

Quantities are adjusted in sections of 2,000 ft. or less, and between summits or other points so chosen that the haul from cut to fill is downhill.

Paved Ditches.—Paved ditches are estimated on steep grades, if the plans or notes show that a considerable amount of water will be carried in the ditches and that the soil is liable to wash. Under ordinary conditions wash is not liable to occur on grades of less than 5 per cent. Paving is omitted for 100 to 200 ft. below culverts. Paved ditches are used in villages if called for in the inspection notes.

Wherever it is necessary to carry the drainage across a public or private drive or a field entrance 12 ft. or more, if necessary, of paved ditch is used.

Concrete Ditch Crossings.—Concrete ditch crossings are estimated for side drains at the less important intersecting highways and also at drives to public buildings or grounds where paving is impracticable owing to depth of ditch. They are not used under private drives.

There are two standard sizes, as follows: Small size, 1 ft. x 2 ft. x 18 ft.; approximate cost, $35. Concrete, 3.25 cu. yd.; 0.155 cu. yd. per each foot added length. Expanded metal; 54 sq. ft., 3.0 sq. ft. per each foot added length. Paving, 2.2 sq. yd. Excavation, 2.0 cu. yd.

Large size, 2 ft. x 2 ft. x 18 ft.; approximate cost, $40. Concrete, 4.1 cu. yd.; 0.192 cu. yd. per each foot added length. Expanded metal, 54 sq. ft., 3.0 sq. ft. per each foot added length. Paving, 2.2 sq. yd. Excavation, 2.0 cu. yd.

Timber Ditch Crossings.—Box timber ditch crossings are estimated at drives and field entrances under some conditions. Their approximate cost is $6. They require 145 ft. B. M. of timber, and 5 lb. of nails.

Bridge timber ditch crossings are estimated at drives or field entrances where a large amount of water must be carried in the ditch. Approximate cost, $15; timber, 375 ft. B. M.; nails, 10 lb.; masonry, laid dry, ⅓ cu. yd.

Guard-Rail.—Guard-rail is estimated where the cross-section shows a difference in elevation of 4 ft., or more, between the crown of the road and toe of slope, and along creeks and dangerous places. At culverts where this rule does not apply 24 ft., each side of the highway, is estimated. Pipe-rail is used only in places where timber construction is impracticable.

Guide-Boards.—Guide-boards are estimated at the intersections of all important public highways with the road to be improved. Inscriptions, showing places to which the State road and intersecting roads lead, with distance scaled from the U. S. Geological sheets to the center of cities or villages, are prepared in proper form.

In preparing inscriptions the nearest village along the State road, especially if it is a small one, is not given on every guide-board, the preferred arrangement being to omit this village on every other board and give the name of the nearest large city or village beyond. At an intersecting road both a nearer small village and a more remote larger village or city may be given. All distances are given to the nearest ¼ mile and no fractions except quarters and halves are used.

A standard road-sign is placed on each guide-board post. Where the guide-board posts are more than approximately ½ mile apart a standard road-sign and post is estimated each ½ mile.

Walls.—Unless local conditions make some other construction advisable dry masonry is estimated for bank walls and concrete or masonry in cement for walls sustaining the road or earth deposited behind them. All walls have a batter of 3 in. to 1 ft. on the face or exposed side and are estimated as extending two feet or more underground in all cases except on rock.

Culverts.—Concrete culverts are used in all estimates. The location and size of culverts are in general directed in the inspection notes. Both are checked with all available data. The size of all large culverts is approximately checked by scaling the drainage area and applying several of the more common run off formulæ for small areas.

No culverts over 30-ft. span are estimated, and none over 15-ft. span are estimated, except after most careful consideration as to the necessity of a new structure.

Plank-floor design is avoided.

In general, when a new I-beam and concrete top is necessary on a large culvert, the existing abutments are also rebuilt, as they are seldom of suitable construction.

The length of culverts is obtained by plotting the culvert on the cross-section and plans.

Existing culverts, permitting approximately 2 ft. of shoulder on each side of the road-surfacing, are not lengthened if otherwise satisfactory.

Preliminary Inspection.—Before the completion of the plans for its improvement, each road is inspected by an experienced engineer detailed from the office force. This is for the purpose of observing the probable effect of the proposed improvement, and of determining the proper arrangement of the drainage system, or any other details which may be a matter of doubt during the preparation of plans.

The inspection is made after the plotting has been completed, and a new grade line has been approximately established, although at the discretion of the engineer in charge of the preparation of plans it may be delayed until after the balancing of quantities. Before commencing an inspection the information obtained by the survey party is reviewed and note made of any failure to secure full information.

The kind and location of available road material is investigated thoroughly, regardless of whether or not the survey party secured information. The profile and the transit book are carried on all inspections and all notes are entered in the back portion of the book. The best results are obtained by walking over the road.

Recommendations are made in every case in regard to the following matters: 1, The kind and width of surfacing and the typical section to be used in improving the road. 2, The location and size of all new culverts and the action to be taken, in each case, regarding old culverts. 3, The changes necessary or advisable in the new grade line, as drawn upon the profile. 4, The location of all necessary underdrains, telford base, deep ditches, or other construction necessary to secure a firm subgrade.

The desire of the local supervisor or other officials in regard to the nature of the improvement is learned, but no assurance regarding the action of the State Engineer is given.

Right-of-Way.—The boundaries of all additional right-of-way to be acquired are drawn on the working plans and traced upon the official plans. A tracing, showing each parcel and giving a description of it, is also prepared in standard form for each separate piece to be acquired. All areas are given to the nearest hundredth of an acre and all dimensions to the nearest tenth of a foot.

Official Plans.—All official plans are drawn in standard form on sheets of tracing cloth of standard dimensions, viz., 24 x 36 in. outside dimensions, with 1½-in. borders except on the left, where a 2-in. border shall be placed. They show progressively from left to right a map and profile of the present and of the proposed improved road, and also the character and location of each detail of the proposed improvement.

The first sheet contains a location map in the upper left corner and a standard form title in the upper center and all sheets contain a standard stamp in the lower right corner, to receive official signatures.

Estimates.—The estimate price for excavation of all kinds is obtained by computing the sum of the estimated earth and rock excavation at 40 cents and $1.50, respectively (these figures may be varied somewhat to suit local conditions), and dividing this sum by the total number of cubic yards of all kinds.

On embankment roads the estimate price for embankment is computed by the following rule: Compute the estimated rock excavation at $1:50 and the earth at 40 cent per cubic yard. (These figures may be varied to suit local conditions. Assume that the rock excavation will form the same amount of embankment (this allows for filling interstices) and that the earth excavation will form three-fourths as much embankment. Find the remaining amount of embankment to be formed from borrowed material, and assume a price for this embankment according to haul and initial cost. Add this estimate to the rock and earth excavation estimates, and divide this total by the total number of yards of embankment to obtain unit price.

The Yosemite Valley R. R. has been finished from Merced on the Southern Pacific to the Yosemite National Park, a distance of 85 miles. It rises 1,900 ft. in that distance.

Autogenous Welding.

The welding of aluminum is generally considered impracticable on account of the film of oxide which forms almost instantly on a fresh surface of that metal, but it has recently been accomplished by the autogenous process at the works of the Worcester Pressed Steel Co., Worcester, Mass. This process depends on the fact that oxygen and acetylene in a blowpipe flame produce the highest temperature (6,300°) of any flame known as a product of combustion. It is 1,200° higher than the oxy-hydrogen flame and nearly equals the electric arc.

This process, which is a novelty in this country, has been found valuable for replacing riveting and brazing in many instances. Two sheets of metal may be welded by placing their edges in contact and following along the seam with a blowpipe. Practically seamless steel and copper tanks of almost any shape and size may be made by forming the body and ends separately and tracing the seams—joints butt and flush—with a blowpipe. Many designs and forms not otherwise possible to construct, are made practicable by this process. This process is especially valuable in the foundry, as the blowholes and similar defects in castings and forgings are made good. Cast iron, wrought iron, steel castings and forgings, copper, brass, bronze and aluminum in many forms of construction are effectively welded, either in the manufacture of new parts or in repairing accidental breaks.

To insure strength, the joint is slightly overloaded by melting a wire or rod of the same material as the metal to be welded, at the same time the edges are fused. The unfinished joint is stronger that the body of the metal itself and the joint when finished has practically the same strength.

A hole of any shape can be easily cut in steel plates up to 6 in. in thickness. In cutting, the flame is proportionately elongated by pressure to penetrate to the bottom of the cut. The intense heat is so localized that the kerf is practically the same as if a saw were used.

The oxygen and acetylene are each generated in a separate apparatus and conveyed through separate pipes to the blowpipe. The distinctive feature which has done the most to make this welding process of wide commercial value is the introduction of a means for producing oxygen. By combining this chemical product with water, chemically pure oxygen is as easily obtained as in uniting calcium carbide and water acetylene is liberated; the chemical reaction in each case being analogous.

The oxygen generating apparatus consists of two lead-lined generating chambers arranged with a scrubber and settling chamber between. In making oxygen, one generator is filled with the required amount of luke-warm water to which one chemical charge is added. While this solution is being stirred with an agitator operated by a crank provided for the purpose, a solution of iron sulphate and water is added which acts as a catalyzer. The oxygen liberated passes from the generator through a scrubber and a water-sealed trap into the gasometer from the gasometer, the oxygen is forced under a pressure of 147 lb. into a storage tank. It is then conducted through ⅜-in. copper piping from which branches of ¼-in. copper piping lead to the blowpipe connections. Reducing valves are arranged so the operator can vary the pressure of the gas at the blowpipe at will. Each blowpipe is supplied with 22 different nozzles so the size and power of the flame are varied according to the thickness of the metal to be welded.

The acetylene generator is of the water-feed type, composed of a cylindrical shaped tank, which serves as a gasometer and regulator, connected by three water supply pipes to three carbide receptacles, half cylindrical in shape, each containing six compartments. Each tray holds about 12 lb. of lump carbide. The acetylene is used under a pressure varying from 2.2 to 3 lb. The pressure is obtained and maintained by two water levels in the gasometer, on the principle of the well-known water column, which automatically governs the supply and pressure of the gas. Any pressure in excess of 3 lb. escapes through a blow-off outside the generator building. From the regulator and gasometer, the acetylene is conveyed through a 1-in. pipe with one ⅜-in. branch leading to each blowpipe connection.

A feature of this acetylene apparatus is a safety valve between the blowpipe connections and the acetylene gasometer. This consists of a 1-in. pipe leading into and two 1-in. pipes leading from a rectangular metal chamber. The inlet pipe connects with the gasometer. One outlet conveys the acetylene to the blowpipe, the other vents to the outside air. The inlet and outlets are separated by a water-sealed trap which prevents any possibility of ignition reaching the generator and gasometer by burning back through the blowpipe supply lines.

The blowpipe is of brass and designed on the injector principle. It is about 24 in. long and weighs 2 lb. It is provided with two inlets which remain entirely separate for practically the entire length of the blowpipe and enter a mixing chamber with a common outlet at the point of combustion.

As acetylene is rich in carbon, containing 92.3 per cent., it is possible when mixed with air in a Bunsen burner, to obtain 3,100° F. In lighting the blowpipe, the acetylene is first turned on full then the oxygen is added until the flame has only a single cone. At the apex of this cone is a temperature of 6,300° F. In welding, this point is held from ⅛ to ¼ in. from the metal to be welded. Too much acetylene produces two cones and a white color; an excess of oxygen is indicated by the flame assuming a violet tint.

Theoretically, 2½ volumes of oxygen are required for the complete combustion of one volume of acetylene. Practically, however, with the oxy-acetylene blowpipe, the best welding results are obtained with 1.7 volumes of oxygen to one volume of acetylene. The acetylene is, therefore, not completely burned according to the reaction $2 C_2 H_2 + 5 O_2 = 4 CO_2 + H_2 O$, but it is incompletely burned according to the reaction $C_2 H_2 + O_2 = 2 CO + H_2$. At the intense heat produced by this combustion, the water and carbon dioxide formed by the first reaction are completely dissociated. To this last fact is chiefly due the success of the oxy-acetylene flame as a welding agent. To establish the proper conditions for autogenously welding two metals, it is necessary to bring them to their melting point without oxidizing or carbureting. As shown by the formula, this flame consists largely of carbon monoxide which is being converted at its extremity into carbon dioxide. This, with the hydrogen, forms a relatively cool jacket, which protects the molten metal and the inner cone from loss of heat.

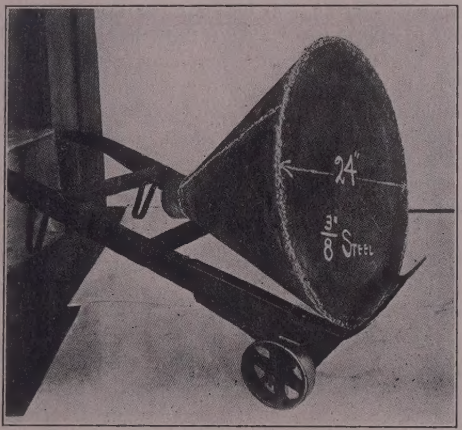
At the moment of initial combustion, when the acetylene is decomposed into elements of carbon and hydrogen, about 300 B. t. u. per cubic foot of the gas are generated. The total heat, however, generated per cubic foot of acetylene is about 1,500 B. t. u., which, aside from the initial decomposition, is furnished mainly by the combustion in oxygen of the carbon dioxide and in lesser degree by the combustion of hydrogen into water vapor. Pure acetylene at a pressure of less than 30 lb., even when passed through pipes at white heat, is perfectly safe, but when mixed with oxygen or air is dangerous. An explosive gas mixture enclosed in a pipe does not inflame at once throughout the entire pipe, but from one end of the pipe ignition travels at a certain speed which increases as the square of the pipe section; therefore, to render safe the use of oxygen and acetylene in a blowpipe flame, the gas mixture is given a speed by pressure greater than the rate of propagation of the flame.

No flux or moulds are required to weld metals such as iron, steel and copper, but for alloys like brass and bronze, a little borax or boracic acid, moistened with water, is used, simply to prevent the volatilized zinc from being deposited on the joint and destroying the weld. This process welds by fusion, forming a metallic union of the parts which is imperceptible after finishing. It is not brazing.

An operator of average ability can weld steel or copper sheets at the rate and cost for gas which the company gives approximately as follows:

Thickness.	Per Hour.	Per Inch.
0.035 in.	288 in.	$0.0031
0.062 "	200 "	.0065
0.125 "	120 "	.016
0.377 "	60 "	.075

Metals ¼ in. and less in thickness can ordinarily be welded cheaper than riveted. Steel and copper tanks of almost any dimensions, for high and low pressure, are effectively welded in place of riveting; broken steel shafts and other forgings repaired, cast-iron welded with copper or steel, and blowholes and similar defects in castings and forgings made good.



Example of Autogenous Welding.

A GREAT EARTH DAM, 1¼ miles long, 150 ft. high, and provided with a concrete core wall, is proposed by the Denver Reservoir Irrigation Co., a company formed by the consolidation of eight large irrigation companies in the vicinity of Denver. The dam mentioned will form a reservoir of about 2,000 acres area, holding water sufficient for the irrigation of over 100,000 acres. The present system of ditches controlled by the company will be utilized to a large extent in distributing this water. The dam will be constructed by the hydraulic fill method, as a ditch near the site of the dam will furnish the water for the purpose and the soil in the vicinity is of good depth and eminently adapted for such a method of construction. About 8,000,000 cu. yd. will be required, and the dam will be between 700 and 800 ft. wide at the base. Construction will be commenced during the summer, and it is estimated that about three years will be sufficient for its completion. J. G. White & Co., of New York, have been largely responsible for making the project an active one and have the contract for constructing the dam and auxiliary work. Mr. W. E. Goldsborough, of J. G. White & Co., will be first vice-president and general manager of the Irrigation Co., the president of which is Mr. Joseph Standley.

Book Notes.

A large number of articles written and compiled for the "Plumbers' Trade Journal" by Mr. Charles B. Thompson have recently been published under the title of "Heating by Steam and Hot Water" in a profusely illustrated quarto book of 265 pages. These have been written for the instruction of steam fitters rather than architects, and embrace a wide range of details. Plans and descriptions are given of installations of heating apparatus in large and small residences, stores, factories and business buildings, methods of figuring the sizes of boilers and pipes are explained, and various features of the work likely to prove of value to an ambitious journeyman or master plumber are discussed in detail. A number of rather poor installations are criticised and a special plea is made for smaller pipe sizes than are customarily employed. (New York, Plumbers' Trade Journal Publishing Co.)

About a year ago attention was called in this journal to a valuable German descriptive work on propellers, entitled "Die Schiffschraube," by Mr. Albert Achenbach. A second volume has just appeared, and a third is promised, the latter to contain the theoretical discussions upon which a considerable part of the contents of the first and second volumes is passed. In the second volume the author takes up the detailing of propellers, and illustrates his points by a large number of drawings and tables based on recent German naval and merchant designs. The book is therefore a valuable help to anybody who wishes to understand the methods of detailing followed by the marine engineers of Germany, and while a few of its statements are decidedly at variance with the views held by American specialists, the volume as a whole will be as interesting to the experienced designer as to the beginner. (Kiel, Germany, Robert Cordes, 14 marks.)

The excellent system of technical indexing done by the "Engineering Magazine" has recently been enlarged by the publication of the first number of the "Engineering Index Annual," covering the contents of technical journals and proceedings of technical societies issued in 1906. In the past the notes published monthly in the magazine have not been brought together in book form more often than every five years, which has been a considerable disadvantage to their use. It is now intended to publish them annually, retaining the classification employed in the "Magazine," instead of using that followed in the volumes previously published. In view of the favor with which this classification has been received the publishers have probably been justified in extending it to the annual volumes, but it is understood that the publication of another quinquennial volume on the same lines as the others is not necessarily abandoned in adopting this differently arranged annual compilation. (New York, The Engineering Magazine, $2.)

Letters to the Editor.

EJECTOR PRACTICE.

SIR: Since writing the letter which you published last week, with the comments of several ejector manufacturers appended, we have given the problem a thorough test and find that the ejector will handle water successfully under the given conditions. We are now lifting an iron solution from tanks to a height of 20 ft. and forcing it into a pipe under a head of about 8 lb. with an ejector supplied with water under a head of about 80 lb. This is being done without any trouble whatever.

SUPERINTENDENT.

Foundations for Asphalt Pavements.

Sir:—Notwithstanding the great value of Mr. Richardson's paper on asphalt, as reviewed in the issue of June 1st, I wish to dissent from the apparent condemnation of the use of old stone pavements as a foundation for sheet asphalt. In the first place an omission should be supplied in the correct statement: "on stone blocks which have been disturbed and turned upon their broader side." This was never done except where stones 2 to 4 in. wide and 6 to 7 in. deep had been laid on 2 in. of sand over concrete. The use of the paving "sets," as they are called in England, laid on their sides saved the necessity of placing from 6 to 8 in. of concrete which was then worth from $7 to $8 per cubic yard on 6 in. of generally satisfactory concrete. As the contractors were willing to guarantee pavements laid on either foundation without preference for 15 years, it seems Mr. Richardson advocates the burial of a structure in our streets costing approximately $4 per foot run which would have been so far monumental that no dividend could be expected from it for 15 years.

The use of Belgian or trap blocks relaid on sand is justified by a consideration of costs. Referring to the "Memorandum of Asphalt Pavements laid in New York (Manhattan) up to January 1st, 1898," (Eng. Record, Nov. 2, 1901), we find that 290,289 sq. yd. of sheet asphalt were laid under a guarantee of maintenance for 5 years, and 2,337,274 sq. yd. with a contract for 15 years' maintenance. Taking for a rough estimate ten streets each on stone and concrete foundation with 5 years' maintenance, the average contract prices were $2.45 4/10 with stone foundations and $3.08 with concrete foundations; a difference of 62.6 cents per square yard. Comparing the same number of 15-year streets, the average contract prices were, with stone foundations, $3.31 9/10 and with concrete foundations $4.50 1/10, a difference of $1.18 2/10 per square yard. These differences applied to the above given areas amount to nearly $3,000,000. With probably others, I am unable to see that the city of New York would have been justified in issuing approximately $3,000,000 additional bonds to secure a better foundation, when the contracts for maintenance covered the same periods for both foundations.

The problem in Brooklyn was different: Its "Pavements fang'd with murderous stones" could not be relaid for asphalt pavements. Those boulders had to go to the crusher. Concrete there was an undoubted economy.

New York, June 9. Edward P. North.

Engineering Advertising.

Sir: May I, through the valuable columns of your paper, call the attention of those manufacturers who are interested in engineering industries, to a very important feature of their business, namely, the sales department, which has incorporated with it their publicity department. When referring to this department, it is perhaps necessary to show from what sources and in what percentage the total business originates. I think it is generally believed that 50 per cent. of the total volume of business originates from personal solicitation, 35 per cent. from advertising, directly and indirectly, and the balance cannot be accounted for, but which is closely allied with the former. Advertising space, being in such constant demand, numbers of publications have sprung up, and the advertisements are simply put there for some reason or another, best known to the manufacturer, without very much attention being given to the design and the information which the advertisement ought to contain.

As a reader depends a great deal upon the advertising columns for information, it ought to be that this information should be more specific, instead of simply referring to a trade mark or a heavy cut of a particular machine or appliance, and as an engineer's knowledge of a machine depends upon the information he can get concerning it, in many cases he has to depend upon the arguments of one manufacturer, because he has neither the time nor the inclination to delve through large quantities of literature which relate collectively to the subject in question.

Regarding catalogues and literature, there is much room for improvement in this respect, as on account of the great competition that exists, a manufacturer must embody in his literature, something more than the superlative term, and as his time is so taken with other features of his business, it remains for him to employ the best talent to illustrate and explain his particular products. In view of the large expenditure a manufacturer is obliged to make in this direction, he ought to make the most of his space and literature, and these sources of publicity should be part of a complete treatise or work explaining his products. My experience in many parts of the world leads me to believe that, in many cases, advertising is looked upon as so much of a speculation, which may or may not pay, but no one can tell whether it does or not, so why bother; and catalogues and literature looked upon as the secret of their business. If instead of trying to outbid each other for the heaviest type in the advertising columns, a manufacturer would try and show his prospective customers by a lucid explanation how they can benefit by using his machine or appliance, it would have a tendency to increase his sales.

The time has come when engineering advertising ought to become a special business itself, in no way allied with general advertising, except from an artistic point of view, and those people who handle it should be engineers of experience, whose ideas do not run to caricatures, or those things which are not consistent with good business. It is not possible for a man to explain and illustrate the merits of a farinaceous food one day, and the next, a semi-automatic capstan lathe. Many large concerns have their own publicity department, which is an excellent thing, but the idea should always be borne in mind that it is necessary to be a specialist in the business you are thinking of becoming advertising expert for, before you take up advertising although in many cases, the applicant is an advertising man, first, and learns the business afterwards. As advertising, direct and indirect, is responsible for such a large amount of business, why cannot it be made more valuable, and be the means of reducing the expense of personal solicitation?

Respectfully yours,

Algernon Lewin Curtis.

Philadelphia, June 15.

Depreciation.

Sir: In your number of June 15 there is an abstract of an article on depreciation by a British author which seems a very valuable one, although how closely his figures apply to the apparatus of electric central stations I am unable to state. The importance of a safe depreciation allowance has been impressed on me a good many times lately in examining the bids submitted for contracts in which I was interested. Ever since graduating from a technical college so many years ago that it makes me feel unpleasantly old to think of the date, I have tried to keep a close watch of the financial part of my work, at first because it was absolutely necessary to husband every penny, and later because the lessons to be learned from cost sheets have been most illuminating. In the last ten years I have lost money on a number of contracts, but I expected there would be some loss when they were signed, and felt that the experience gained in certain lines would justify the expense. The money has not been badly invested which went into the losses on such pieces of work, in my opinion, for the knowledge gained in this way has saved large losses on more important jobs. The habit of keeping detailed cost sheets on all work has enabled me to see just where an organization or a certain class of equipment was strong or weak for a certain kind of work, and to change it if it was poor until something better was discovered, and the detailed figures have shown repeatedly that without making a proper allowance for depreciation of equipment, certain classes of contract work become mere gambles.

The author of the article you printed last week stated that unless proper allowances were made for depreciation, the manager of an electric lighting company could not tell whether he was making or losing money. This is just as true of some kinds of contract work, particularly that done under conditions which require a large plant that cannot possibly be kept working all the time, as in making extensions or alterations in a large railway yard or in a street where traffic cannot be wholly kept away. I have seen work trains and the shovels supplying them held up for long periods in a busy yard, the delay costing the contractor more than his profits for several days' steady prosecution of such work. Many of your readers have probably seen expensive trench machines at work in streets on small jobs which could be more economically, although less rapidly, completed without their use. All such equipment represents a large initial expense and unless the contractor is able to estimate how much it will cost to keep it in repair and what it will sell for when the work is done, how is he to know very much about his profits? To my mind the feature of estimating on which most contractors are weakest relates to plant, for they do not allow for its enormous fixed charges and depreciation. From 1900 to 1906 second-hand equipment brought unprecedent prices, but they have begun to drop back to their usual level now and this depreciation will greatly reduce the expected profits on some large contracts which will soon be closed up, unless the labor charges have been kept very low through fortunate circumstances.

All contracts for works which are difficult to execute on account of complicating conditions differ greatly from those where all the contractor has to do is to supply a suitable number of men and teams, work trains, a shovel or two and some camps. Where it is necesary to denude a good bit of timber land to supply the beams and sheathing needed for difficult excavations, to install an electric plant for power and lighting, put in compressors, derricks and drills, and to resort to all kinds of measures to keep the work from disturbing travel or injuring neighboring buildings, the bills for materials and equipment mount up rapidly, and it is vital in times of sharp competition to avoid underestimating the depreciation charges which should be made against such items. During the last year I have cleaned up two contracts for bonding companies on both of which I originally figured, and had the satisfaction of learning in each case that my estimates of the cost of the work were right. The unsuccessful contractors neglected in both cases to allow for delays with their attendant interest charges, for depreciation in plant, and for the increase in the price of good labor.

Contractor.

Steel Rails shipped to the Argentine state railroads from eastern ports of the United States in the month of March of this year amounted to over 17,000 tons.